THE INTERNET AS AN INFORMAL LEARNING ENVIRONMENT: ASSESSING KNOWLEDGE ACQUISITION OF SCIENCE AND ENGINEERING STUDENTS USING CONSTRUCTIVIST AND OBJECTIVIST FORMATS

By

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Dr. John J. Koran, Jr.

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This study examined the effects of two different instructional formats on Internet WebPages in an informal learning environment. The purposes of this study are to (a) identify optimal instructional formats for on-line learning; (b) identify the relationship between post-assessment scores and the student's gender, age or racial identity; (c) examine the effects of verbal aptitudes on learning in different formats; (d) identify relationships between computer attitudes and achievement; and (e) identify the potential power for self-regulated learning and self-efficacy on Internet WebPages.

Two learning strategy modules were developed: a constructivist and an objectivist instruction module. The study program consisted of an on-line consent form; a computer attitude survey; a Motivated Strategies for Learning Questionnaire; a verbal aptitude test; a pre-assessment; instructional directions followed by the instructional module and a post-

assessment. The study tested 145 post-secondary science and engineering participants from the University of Florida. Participants were randomly assigned to one of two treatment groups or a control in a pretest/posttest design.

An analysis of covariance with general linear models was used to account for effects of individual difference variables and aptitude treatment interaction (ATI). This statistical procedure was used to determine the relationships among the dependent variable, the achievement on each of the formats and the independent variables, attitudes, gender, racial identity, verbal aptitudes, and self-regulated learning/self-efficacy. Significant results at $\alpha = .05$ were found for none of these variables. However, a linear prediction of age shows that older participants scored higher on the post-assessment after completing the objectivist module. Although there were no significant differences between the learning format and the variables, there was a difference in achievement between the modules and the control. Therefore, it is possible that regardless of characteristics, science and engineering students can learn on-line technical material.

CHAPTER 1
INTRODUCTION

The Internet, the World Wide Web and Cyberspace

Although the quality of information available on the Internet has been questioned, Cyberspace has truly opened an information highway. Technology has gained attention in education today because of its prevalence; its promise to provide low cost education; and it may help some people to participate more easily, to learn more effectively, and to enjoy learning more (Palmieri, 1997). Given adequate access to technology, the Internet, the World Wide Web (WWW), and Cyberspace can provide both teachers and students with an ever-growing resource of information. Teachers can introduce and use information from the WWW for instruction and supplementing almost any subject matter. Used effectively, this environment has the potential to level the playing field for education in rural communities that typically lack the resources found in major metropolitan areas.

> Imagine the student sits at a classroom computer grazing the Internet--a global network linking the student with vast databases. Schools are rushing to install networks and Internet nodes so that all classrooms might sit down to sample the electronic feast. How might we take advantage of the Internet to raise a generation of free-range students? The rich information resources to be found in Cyberspace are both a blessing and a curse. Unless students have a toolkit of thinking and problem-solving skills, which match the feasts of information, they may emerge from their meals bloated with techno-garbage, information junk food or info-fat. We must teach students to graze and digest the offerings thoughtfully in order to achieve insight. For the computer to bring about a revolution in higher education, its introduction must be accompanied by improvements in our understanding of learning and teaching. (Simon, 1996, p. 23)

Three issues of particular concern to educators emerge in using the seemingly infinite resources available on the Internet and WWW. The first concern relates to information overload and lack of useful instructional format; the second concern relates to identifying the necessary skills and attitudes to enable users to critically evaluate and use the resources; and the third is to effectively design and evaluate different learning formats. Access to the WWW has the potential to change how educators think of themselves, their roles, and their instructional techniques. Learning through the Internet provides the flexibility and efficiency of computer instruction as well as individual attention of traditional instruction (Huang, 1997). Instructors could be more than knowledge providers, as the WWW could allow them to devote attention to a more global facilitation of learning such as appropriate presentation formats. McDonald and Ingvarson (1995) found that technology may have the potential to free teachers from the moment-by-moment demands of whole class teaching, enabling them to concentrate on challenging students and catering to students as individuals. The WWW and subsequent electronic media can move beyond didactic instruction to model directly the modes of inquiry made easier with computers. Also, by including the Internet and the WWW in classrooms, teachers can assist students in becoming active participants in the construction of their own knowledge. Results have shown that Internet use can increase post-secondary student performance on learning in science concepts (Follansbee, 1997). This increase can be related to using the Internet as a supplemental resource for students to use to conduct their own forms of investigative inquiry. By using it as a tool, the information available through the Internet provides a wealth of resources for both students and teachers to

search and research issues and topics of concern. The nonlinear organization of text and graphics on the Internet allows greater user control and learners may be motivated to engagement. However, materials must be presented clearly by establishing relational paths without eliminating multiple selections. A constructivist approach permits this and the freedom to explore (O'Carroll, 1997). Authentic research and learning activities used to promote inquiry and knowledge construction by these approaches can be motivating for Internet users.

One note of caution--some educators are demonstrating academic anxiety about the information age. Novek's (1996) study suggests that the expansion of the information economy is a cause for deep concern in higher education. If educators are to take full advantage of the interactive characteristics of new technology then we must do more than simply adapt the technology to old styles of pedagogy.

The Interface Between the Internet and Informal Settings

The new computer aspect of pedagogy is not without precedence. In essence, the approach to accessing useful information through the Internet is analogous to learning in other, more familiar, informal settings. Informal settings are typically places where learning takes place in out-of-school settings, such as museums, zoos, aquaria, science and technology centers, homes, and clubs. They are also characterized by intrinsic motivation, the content is variable and possibly unsequenced, attendance is voluntary, displays and objects are provided, learners of all ages may participate, and there is more diversity in the learners' backgrounds. Therefore, the freedom or "free choice" environment which the

learner finds in a museum setting is similar to the freedom one may experience in an Internet setting, providing multiple options, or links in which to direct his or her attention.

Attention is a necessary prerequisite for learning. Attention and engagement are pivotal to perception and coding, which are involved in the subsequent retrieval of information. Even though museums have existed for many years, actual learning in museum research is relatively new. Koran, Longino, and Shafer (1983) have found that a considerable amount of sensory stimulation, learning, and affect appears to be influenced in these "free-choice" settings. Shettel (1996) suggested that time on task (i.e., holding power) have been found to be one of the most useful predictors of educational effectiveness. Similarly, Falk (1983) found that both the time spent at an exhibit and the nature of the interaction affect the amount of learning which occurs. The time and stops at a museum can be equivalent to the duration and engagement of a WWW homepage. Falk and Dierking's model (1992) suggested that visitors construct their own unique meaning for the visit experience according to personal background and interaction with their social and physical environment. They have found that memories from visits to informal learning settings are persistent in the minds of children and remain with them into adulthood. Thus, by applying appropriate educational theories, this lifelong learning is another strong argument for the importance of learning in informal settings.

Application of appropriate educational learning theories is critical for instruction in informal settings. A firm theoretical foundation offers teachers a starting point from which they can build a series of learning opportunities, responding to all styles and encouraging a wide range of strategies in order to encourage successful learning. Innovative approaches plus access to appropriate technologies will lead to the creation of new learning

environments that are flexible and provide a custom education for each student, regardless of class size, time and distance constraints, previous preparation, and personal factors. Selection of appropriate technologies should be defined by the desired learning outcomes and students' needs to perform tasks according to their individual styles and strategies, not because the technology may provide an alternate "fun" approach to learning. Rather than depend on a single set of materials and activities within a content area, all learning becomes interdisciplinary as students expand on prior knowledge, pursue interests, combine information in new ways to solve problems, and reach new understanding of old knowledge. Learning becomes a dynamic, customized pursuit of new solutions rather than the acquisition of a preconceived package of facts. Learners may become teachers within a new cycle of exploration and discovery. Technology may add the tools that facilitate access to the people, content, strategies, activities, guidance, and opportunities to apply new information that make learning a personal process.

However, passively hoping that learners will be able to activate appropriate learning strategies in an informal learning environment without guidance is insufficient to ensure successful learning and development. Instead, strategy development and application can be actively included in learning opportunities. In this light, appropriate technologies can enable teachers to provide students with choices as to when, where, and how they access information. These choices allow students to apply a variety of strategies that help organize and advance the learning event. This type of "self-regulated" learning can become a vital and enhancing part of learning through computers. In this manner, it offers a natural indoctrination into this helpful learning style which has shown success in other venues, but has been difficult to incorporate into student skill sets.

There are several characteristics of computer technology that make it a desirable vehicle for examining the concept of self-regulated learning. Self-regulated learning is not a mental ability, such as intelligence, or an academic skill, such as reading proficiency; rather, it is the self-directive process through which learners transform their mental abilities into academic skills (Schunk & Zimmerman, 1998). Computers make it possible to independently store data collected via interaction with the student thus providing the possibility for following student moves as a source of data and later providing feedback to them. This capability has instructional benefits: first, learner interaction with concepts can be stored and retrieved for later analysis; and second, the immediate feedback that the learner receives allows a greater degree of learner control by providing individualized opportunities for review. McDonald and Ingvarson (1995) found that independent learning of this type has a strong chance of success due to the extended resources which the computer offers. Theoreticians seem to agree that the most effective learners are self-regulating (Zimmerman, 1996; Winne, 1995). In academic contexts, self-regulation is a style of engaging with tasks in which students exercise a suite of powerful skills: setting goals for upgrading knowledge; developing strategies; and, as steps are taken and the task evolves, monitoring the accumulating effects of their engagement. As these events unfold, obstacles may be encountered. It may become necessary for self-regulating learners to adjust or even abandon initial goals, to manage motivation, and to adapt and occasionally invent tactics for making progress. Self-regulated students are thus aware of qualities of their own knowledge, beliefs, motivation, and cognitive processing. This awareness provides grounds on which the students judge how well unfolding cognitive engagement

matches the standards they set for successful learning (Corno, 1994; Howard-Rose & Winne, 1993; Zimmerman, 1989).

Purpose

The purposes of this study are to (a) identify optimal instructional formats for on-line learning; (b) identify the relationship between post-assessment scores and the student's gender, age or racial identity; (c) examine the effects of verbal aptitudes on learning in different formats; (d) identify the relationships between computer attitudes and achievement; and (e) identify the potential power for self-regulated learning and self-efficacy on Internet WebPages.

Although the information processing theory (attention, knowledge acquisition, and retention), self-regulated learning and constructivism have been previously examined in other educational settings, this research study adds to the literature because it translates these approaches and their usefulness into the informal setting of Cyberspace.

Statement of the Problem

Developments in media and communication technologies are set to revolutionize education. With modern technology, it is possible to deliver lectures, assignments and information to anyone in possession of a modem and computer (Rose, 1996). The significance of this new technology with respect to education is the ability of the educational superhighway to provide on-demand service; automate assessment techniques and improvements to instructional strategies. Although there is still a way to go in

building the education superhighway, the type and usefulness of the material available through the Internet should be considered now.

A Report to the Nation on Technology and Education (Dept of Ed, 1996) on technological literacy states that computer skills and the ability to use computers and other technology to improve learning, productivity, and performance has become as fundamental to a person's ability to navigate through society as traditional skills like reading, writing, and arithmetic. The Technology Literacy Challenge envisions a 21st century where all students are technologically literate will require the fulfillment of four main goals: (a) all teachers in the nation will have training to help students learn to use computers and the Internet; (b) all users will have modern multimedia computers in their classrooms; (c) every classroom will be connected to the information superhighway; and (d) effective software and on-line learning resources will be an integral part of every school's curriculum. A partnership between the private sector, state government, local communities, and the federal government is necessary to achieve these technological goals.

Sherritt and Basom (1997) proposed that the use of the Internet by colleges and universities for delivery of distance education is one trend likely to continue. Unlike previous educational trends driven by research and tradition inside the academic community, Internet use for education is enthusiastically supported by forces outside of academe. The most widely used practices are formal courses, self-directed learning, on-line lecture notes, newsgroups, electronic mail, and virtual reality. Both advantages and limitations apply to Internet learners, educators, and institutions. The economy to offer classes to hundreds of learners is balanced by the enormous costs of establishing and

maintaining an infrastructure to manage it. The advantage to learners of acquiring customized education at their convenience is offset by the need for expensive equipment to access the curriculum. The list of established universities adopting or seeking to adopt WWW courses for distance delivery is long. The issues, which are yet to be well researched, are cost effectiveness, quality of learning, accreditation, access, curriculum, assessment, and effective learning formats.

In this age of information, the need for technical skills has put new burdens on our schools, families and communities. The traditional view of education as an activity for the young has been modified by contemporary demands for lifelong learning. How well will we equip the youth to assume the burden of learning for themselves (Zimmerman, Bonner, & Kovach, 1996).

If you give a man a fish, you feed him for a day. If you teach a man to fish, you feed him for a lifetime (Confucius, 551-479 B. C.). Self-regulated learning is an attempt to teach students how to feed their hunger for knowledge for a lifetime. Self-regulation is inherent when learning is guided by goals of any sort (Winne, 1995, 1996). As stated earlier, there are several characteristics of computer technology that make it a desirable vehicle for examining the concept of self-regulated learning. Appropriately configured, computing technologies can be efficient vehicles for academic instruction. However, today's technologies provide more than this, as we are now able to structure systems students can use to design their own instructional activities. These designs for self-instruction are clear evidence of self-regulated learning (Winne, 1998).

Like conventional tools' students use to learn, Winne and Stockley (1998) indicate that now they will need to be taught how to use computing technologies. Ehley (1992)

proposes that effective integration of technology as a learning/teaching tool requires present and future educators not only to be trained in computer use but also to have effective and practical model's integration of useful learning strategies. Therefore, appropriate, fundamental learning strategies are the best approaches for developing educational material on the Internet. Furthermore, education on the Internet should emphasize self-regulated learning and capitalize on the strength of an inherent "free-choice" environment which the WWW supports.

Definition of Selected Terms

For the purpose of this study, the following terms are defined as follows:

Cyberspace is the nebulous "place" where humans interact over computer networks, synonymous with virtual space.

Internet is a worldwide network of networks that allows users to move files from one computer to another by File Transfer Protocol (FTP), an application program that uses Transmission Control Protocol (TCP/IP), a protocol which makes sure that packets of data are shipped and received in the intended order. It is used with Internet Protocol (IP), the underlying packet standard used to connect networks over the Internet. IP is half of a protocol suite that works and must work with TCP, a protocol to allow you to move files from a distant, host computer to a local computer. A host system is a network computer that can receive information from other computers. Files that are used on the Internet are typically in a HyperText Markup Language (HTML), the programming language used to create web pages. Hypertext Transfer Protocol (HTTP) is the protocol used to provide hypertext links between web pages on-line.

On-line is a buzzword that indicates access to a computer network. A network is a series of points connected by physical or virtual connects on the World Wide Web.

World Wide Web (WWW) is a multitude of independent electronic servers (a computer with a special service function on a network, generally receiving and connecting incoming information traffic) which offers an interactive environment that reflects divergent perspectives and multiple constructions of reality. The WWW removes traditional barriers that isolate children and classrooms from the outside world and provide opportunities to build new networks of communities premised on shared interests rather than being constrained by geographical proximity.

Web Homepages are the top-level hypertext document in a collection of pages or web site. Homepages often use index.htm as a file name.

Internet Address is a set of numbers or letters know as the Internet Protocol (IP) address. The IP address enables you to search, locate, and connect to a specific computer.

Self-regulated learning has been defined by Corno and Mandinach (1983) as an effort to deepen and manipulate the associative network in a particular area and to monitor and improve that deepening process. It refers to the deliberate planning and monitoring of the cognitive and affective processes that are involved in the successful completion of academic tasks. Strategies include self evaluation, organizing and transforming, goal-setting and planning, seeking information, keeping records and monitoring, environmental structuring, self consequating, rehearsing and memorizing, seeking social assistance, and reviewing records (Zimmerman, 1989).

Informal Settings are typically places where learning takes place in museums, zoos, aquaria, science and technology centers, homes, and clubs. They are also characterized as

places where motivation is internal, the content is variable and possibly unsequenced, attendance is voluntary, displays and objects are provided, learners are of all ages, and there is more diversity in the learners' backgrounds (Koran & Koran, 1988).

Attention is the focus on a stimulus. Gagne (1973), Keele (1973), and Bransford (1979) maintain that the first step in a sequence of learning and memory events is for the learner to attend to a stimulus.

Knowledge is an interaction between subject and object; a perpetual construction made by exchanges between thought and its object; a reconstitution of reality by the concepts of the subject, who, progressively and with all kinds of experimental probes, approaches the object without ever attaining it in itself (Bringuier, 1980).

Retention requires coding and transforming modeled information for storage in memory, as well as cognitively organizing and rehearsing information. Retention is increased by rehearsing information to be learned, coding in visual and symbolic form, and relating new material to information previously stored in memory.

Free-Choice is a modified term used in informal setting environments that emphasizes the freedom which the learner has at choosing the particular exhibits in which to attend, engage, discover and incorporate. This term is often analogous to constructivism in a formal classroom setting.

Constructivism is defined as instruction calibrated to the conceptual understanding of the student. The basic idea of constructivism is that the learner must construct knowledge, the teacher cannot supply it (Bringuier, 1980). Constructivism stresses the interaction between learner and the environment and learning is embedded in the context in which it occurs. Thereby learners are encouraged to develop their own understanding

of knowledge. A true constructivist environment in Cyberspace would allow the user to access any and all areas of the Internet. However, for this study, a constructivist environment has been operationally defined as one which allows the user (participant) to access several internal links to build their knowledge of the subject.

Structure has been defined by Briggs (1967) as the description of the dependent and independent relationships among component competencies, arranged so as to imply when sequencing can be random or optional and when sequencing must be carefully planned, on the basis that transfer will be optimal in order to build up from simple skills to more complex ones.

Objectivism holds that the world is completely and correctly structured in terms of entities, properties, and relations (Duffy & Jonassen, 1991), and that knowledge is stable, staying independent of the individual because the essential properties of objects are knowable and relatively unchanging. It assumes that people can gain the same understanding, and this understanding can be completed when rational or "systematic rules are used to draw conclusions" (Winograd & Flores, 1986).

Museums are public places of interest for the purpose of conserving, studying, interpreting and exhibiting to the public for instruction and enjoyment. These places may include zoological parks, aquaria, and science centers (Ambrose & Paine, 1993).

Significance of the Study

The Internet is the fastest growing market in the world. IntelliQuest Information Group, Inc. (NASDAQ: IQST) have provided the following statistics:

(a) The use of the Internet and on-line services in the U.S. show 62 million adults or 30% of the population are on-line as of the fourth quarter of 1997. This represents a 32% growth from the 46.8 million users reported one year ago. Anticipated growth predicts the number of wired U.S. residents could approach 70 million by mid-year; (b) The majority of users (80%) are located in the U.S., with 10% from Europe, 5.5% from Canada & Mexico, and 1% Asia; (c) Approximately 57% of the Internet users are male, and the average age is 35; 88% have more education than a high school diploma; 66% of users have a college degree, 20% have a master's degree, and 7% have a Ph.D.; approximately 50% of users have personal incomes of $50,000 or more and 65% have incomes greater than $35,000; (d) About 50% of the on-line population in the U.S. spend about 5 hours per week on-line, with most surfers sacrificing their television intake; (e) There is one person joining the Internet community every 1.89 seconds, 20-40,000 new users per day, 1,002,612 Web sites active as of April 97; (f) Over 80% of businesses in America have and use a computer for their business. Nearly half of the homes in America have a computer in them.

The increased use of computers and electronic information in society today is evident everywhere and the educational environment is no exception to that expansive growth and influence. Computer systems are extremely useful because of their ability to rearrange or summarize data for subsequent human analysis. However, they cannot turn bad data into truth anymore than humans can. Hence the old saying, "Garbage In, Garbage Out" (GIGO), is well known in the computer world. As quickly as electronic information was being processed, it was just as rapidly evaluated and sometimes discarded as garbage. Systems were not inherently effective; they require an organized plan, a

quality process and follow through, but most importantly the type of input information had to be accurate. If the information or programming was not correct--or garbage, one could not magically expect to be provided with sound responses. The computer was hailed as the most advanced system and the most ignorant at the same time, because it could only know something if it was told what to know. The parallels between the field of education and computers are numerous. A teacher cannot expect to receive appropriate responses from the student if they are not first presented with the correct information initially. Therefore, when combining the flaws of a computerized system with learning, it becomes even more critical that educational programs and assessments incorporate quality input in order to produce reliable, quantifiable output. Curley and Strictland (1986) provided guidelines for understanding computer-assisted instruction (CAI) pedagogical designs and evaluating CAI software for its relevance to specific teaching and learning objectives keeping in mind the GIGO theory.

The Need for Internet Research and Evaluation

To date, there has been little or no quantitative evidence in research for examining self-regulated learning of different learning strategies in the informal setting of Cyberspace. With the threat of a massive influx of uses for advanced electronic media in the classroom, an abundance of qualitative research was performed, resulting in basic subjective conclusions on the possibilities of this technology. Much of this work has been performed in areas concerned with attitudes, gender, aesthetics, and the format of WebPages. In addition, other studies were directed toward hypermedia systems, including elements of presentation such as text structure, readability, fragmentation, and text

displays (Oliver & Herington, 1995); or the effects of font size in a hypertext environment (Chen, 1996). Also, many technical journals described the ideologies of electronic mail, chatrooms, Listservices, and networks (Chau, 1997; Block, 1997; Wilson, 1997). However, the next step in quantifying practical, functional usage of Internet technology as it specifically relates to educational objectives has not yet been performed. Winne (1993) admits that little is known about instructional design issues that affect student's learning with technology. Weinstein (1996) agrees that relatively little is currently known about the development or acquisition of self-regulation and what can be done to facilitate its development with new technology. After illustrating how today's computing technologies might support how students become self-regulated learners, Winne (1998) admits that these hypotheses need empirical study. Therefore the key to instructional power of computer technologies will be in the basic research.

In 1989, Zimmerman and Schunk edited the first book devoted to this topic in formal, traditional settings. They assembled key theorists offering a range of perspectives on how students self-regulate their academic functioning. One purpose of that volume was to provide theoretical direction to ongoing research as well as efforts to explore academic self-regulatory processes. The second volume edited by Schunk and Zimmerman (1998) offers the fruits of the first generation of research as well as how self-regulation differs from such related constructs as motivation and metacognition, and whether students can be taught self-regulatory skills. Winne and Stockley (1998) discuss computer technologies as sites for developing self-regulated learning, and although they use examples of computers involving Internet and WWW usage, there is not a direct approach concerning the importance of self-regulated learning on the Internet as an

informal setting. In addition, the narrow balance between choice (constructivism) and structure (objectivism) in creating successful environments that encourage self-regulated learning is an area of needed professional development (Lebeau & O'Donnell, 1997).

Therefore, the combination of these inevitable resources--learning styles (constructivism versus objectivism), a learning strategy (self-regulation), and a learning environment (Cyberspace as an informal setting) appear to be a worthwhile venue for quantitative educational research.

CHAPTER 2
LITERATURE REVIEW

Information Processing

One assumption of human information processing (IP) theory is that it is analogous to computer processing, in that it receives information, stores it in memory, and retrieves it as necessary (Schunk, 1996). The IP theory is referred to as the learning and memory model which has been used to describe learning in informal settings by Koran, Longino, and Shafer (1983) from Gagne (1970, 1973), Keele (1973), and Bransford (1979). The theoretical basis for this research study uses the assumption stated as an assessment tool to investigate learning strategies through electronic media via web pages as an effective informal learning environment. The generic state of the IP system is commonly referred to as the two-store (dual-memory), originally proposed by Atkinson and Shiffrin (1968, 1971). Figure 2-1 represents a modified version of this model emphasizing the attention, learning acquisition and retention facets of this study.

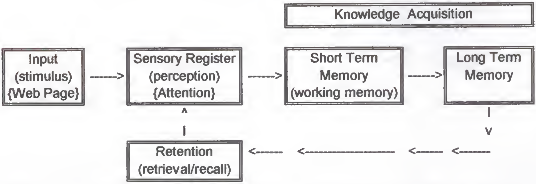


Figure 2-1. IP Model of Learning and Memory (Atkinson and Shiffrin, 1968, 1971)

The IP theory views learning as the coding of information in long term memory by creating schema produced by relating new knowledge to existing information in the short term or working memory. Short term memory, or working memory, is the information that you are focusing on at a given moment. A part of the working memory, the sensory memory is a system of receptors holding sensory information very briefly. Long-term memory is where knowledge is permanently stored. Procedural memory is long-term memory for how to do things or processes.

Albert Bandura (1977) established that there were certain steps involved in the memory modeling process: (1) Attention: if you are going to learn anything, you have to be paying attention. Likewise, anything that puts a damper on attention is going to decrease learning, including observational learning, such as distraction from competing stimuli. If the model is colorful and dramatic, for example, we pay more attention. If the model is attractive, or prestigious, or appears to be particularly competent, you will pay more attention. And if the model seems more like yourself, you pay more attention; (2) Retention: the ability to retain and remember what your attention had selected. Typically, we store what we have seen the model doing in the form of mental images or verbal descriptions. When so stored, you can later "bring up" the image or description, so that you can reproduce it with your own behavior; (3) Reproduction: you have to translate the images or descriptions into actual behavior. So you have to have the ability to reproduce the behavior in the first place; and (4) Motivation: intrinsic and/or extrinsic will increase the rate at which you attend, retain and reproduce.

Although the schematic, which represents the IP theory, appears relatively simplistic, there are many parameters which are included in each phase. The factors which are discussed in this literature review are attention (including stimulus, engaging, holding power, and perception); knowledge acquisition or learning which encompasses both short term (rehearsal, repeating) and long term memory (elaboration, note-taking, mnemonics, imagery); and retention (including retrieval, recall, remembering). In addition, a discussion of two learning strategies, free choice (constructivism) and structured (objectivism), will be compared in the informal learning environment of Cyberspace. This research focuses learners in an informal learning environment. An informal learning environment will be defined and discussed later in this section: however it should be noted that although many of the previous research in this area takes place in museums, zoological parks, aquaria and science centers, the role and analogy of the computer as an informal learning setting will be included in this study.

Attention

Attention is the focus on a stimulus. People's attentional capabilities are limited; they can only attend to a few stimuli at a given moment. A stimulus is an event that activates behavior. To initiate a learning activity, one must first provide a suitable stimulus to attract the attention and arouse the curiosity of the learner; thus attention is a necessary prerequisite of learning. As Gagne (1973), Keele (1973), and Bransford (1979) point out, the first step in a sequence of learning and memory events is for the learner to attend to a stimulus. LaBerge (1997) proposed that attention to an object requires the simultaneous activity of three brain regions that are interconnected by a triangular circuit.

The regions are the cortical site of attentional expression, the thalamic enhancement structure, and the prefrontal area of control. In the same study, it is also proposed that the additional component of attention directed to a representation of the self be included.

Curiosity plays a role at this point by acting as both a response to a stimulus and a factor for influencing further attention. As Koran and Longino (1983) found, the greater the complexity of the object, the higher degree of curiosity it will evoke. They also compared the time spent as a measure of attention to time in the vicinity of the stimulus can be a measure of curiosity. Further, Koran and Koran (1984) demonstrated that curiosity is a response to a novel stimulus, such as manipulatable objects found in informal settings. This stimulus will increase the amount of attention to the object. Koran (1984) also proposed that static stimuli influence attention for only a short period, thus coding is minimized and information storage and retrieval is low. Likewise holding power, and engagement time, or the time spent actively learning, will also be limited.

An early study by Shettel et al. (1968) describes exhibit effectiveness as being dependent on the initial attracting power, subsequent holding power, and teaching effectiveness of the exhibit. Holding power is defined as the total time spent at an exhibit. Other studies have been performed attempting to attract visitor attention with a variety of methods such as using audio or participatory schemes (Screven, 1974a, 1974b, 1975; DeWard, Jagmin, Maistro, & McNamara, 1974); recessed objects (Dierking, Koran, Lehman, Koran & Munyer, 1984); manipulation of objects (Dierking, 1987; Koran & Koran, 1984; Koran, Koran & Longino, 1986; Koran & Longino, 1983; Koran, Morrison, Lehman, & Koran, 1984); interaction of visitors with exhibits (Birney, 1993; Boisvert & Slez, 1994, 1995; Dierking & Falk, 1994; Their & Linn, 1976); modeling (Koran, Koran,

Foster, & Dierking, 1988); and using exhibit interpreters (Bennett, 1989). In addition, the length of attention has been found to be more important than interest in determining learning (Koran, Foster, & Koran, 1989); and providing links to prior knowledge has been shown to focus attention and increase learning (Ellis, 1993; Ham, 1983; Jenson, 1982; Koran, Koran, & Foster, 1989; Koran, Lehman, Shafer, & Koran, 1983; Miles & Tout, 1993; Screven, 1986).

In another study, Serrell (1997) proposed that the amount of time visitors spend and the number of stops they make in exhibitions are systematic measures that can be indicators of learning. The time and stops at a museum can be equivalent to the duration and engagement of an Internet web page. In addition, Serrell (1997) points out that unless visitors get some enjoyable, provocative, or personally meaningful feedback from an exhibition, their attention will turn elsewhere; or if their exhibit challenges are not matched to their skills, visitors will not pay attention.

In order to reinforce the importance of attention, Shettel (1996) suggested that time on task (i.e., holding power) has been found to be one of the most useful predictors of educational effectiveness, and it has been used for this purpose in countless studies. Although holding power has been shown to be an important factor in learning, it cannot work effectively by itself. Attention must be focused by the use of colors, shapes or arrows (possibly motion or animation) on relevant features of the exhibit in order to increase the potential for effective learning (Koran & Lehman, 1981). Olson and Bialystok (1983) found that pictures contain amounts of information but attention must be directed to the visual details of the picture to enable decoding of this information from the picture. The perceptual prominence of an item can be adjusted through the variables of

size, position and value thereby influencing the order of processing individual pieces of data. People use the visual and spatial characteristics of graphical layouts to express relationships between object, icons, or other representations of underlying information (Shipman & Marshall, 1995). Attention to instructional materials can also be monitored via the computer. Dern (1997) reminds us that on-line users leave traces that others can find and use for assessment. This fact will be used in this study to assess learner flow and correlate time and attention to post-assessment scores.

Another aspect of attention is perception. Perception, which precedes coding, is the use of all of the senses to acquire information about the stimulus. It is also the mental grasp, awareness and decoding information and thereby depends on objective characteristics and prior experiences. Information in this instance could be anything from visual questions, pictures, or sensory stimuli. It is an active process and one that is an intrinsic part of learned behavior. Relevance in visual processing is all about being able to discriminate relevant features of an object, structure, image and through combining these features, deciphering an idea of the whole. Perception is an active process, not merely a passive response to visual input but the result of hypothesis formation and testing conditioned by our expectations (Bodecker, 1995). Perception is fundamental to interacting with computers as one needs to perceive the information at and through the interface (Preece, 1994). The information has to be presented in such a way as to avoid ambiguity. Good graphics usually means linking perceptual cues to important information, which means both identifying and capturing what are important, and guiding the reader with appropriate cues (Petre, 1995). Technology does not change the way people perceive information; it can, however, enhance that perception through a combined effort.

The power of the recent technological surge of computers is that it produces the ability to combine various types of information, thereby surpassing social coding as the only creator of meaning.

Finally, attention is not only critical as a precursor to learning, but in addition it has been found to operate at both encoding and retrieval (Boronat & Logan, 1997). The importance of this factor will be discussed in following sections.

Knowledge Acquisition

Piaget (1974) defined knowledge as an interaction between subject and object; a perpetual construction made by exchanges between thought and its object; a reconstitution of reality by the concepts of the subject, who, progressively and with all kinds of experimental probes, approaches the object without ever attaining it in itself (Bringuier, 1980). In this respect, a concept is a general category of ideas, objects, people, or experiences whose members share certain properties.

Knowledge acquisition is part of learning. Learning is a process through which experience causes permanent change in knowledge or behavior that is not explained by development alone. Shuell (1986) defines learning as an enduring change in behavior, or in the capacity to behave in a given fashion, which results from practice or other forms of experience. Learning involves the acquisition and modification of knowledge, skills, strategies, beliefs, attitudes, and behaviors. Learning also involves cognitive, linguistic, motor and social skills and can take many forms (Schunk, 1996). However, Brooks and Brooks (1993) indicated that knowledge is temporary, developmental, and relies heavily on social and cultural factors. Schunk, 1996 also states three criteria for learning to take

place: behavioral change, or change in the capacity for behavior; the enduring change over time; and change due to practice or other forms of experience.

Learning occurs through either behavioral or cognitive theories. Behavioral theories view learning as a change in the rate, frequency, or form, primarily as a function of the environment and contend that learning involves the formation of associations between stimuli and response. Skinner's (1953) view was that a response to stimuli becomes more likely to occur as a function of the consequences of responding. In contrast, cognitive theories stress the acquisition of knowledge and mental structures and the processing of information and beliefs. A central theme in cognitive theories is the mental processing of information: its acquisition, organization, coding, rehearsal, storage in and retrieval from memory, and forgetting. For the purposes of this study, only cognitive theories will be discussed.

Cognitive theories contend that instructional factors alone do not fully account for students' learning (Pintrich, Cross, Kozma, & McKeachie, 1986). In other words, how students attend to, rehearse, transform, code, store, and retrieve information is critically important. Other important instructional principles may include active involvement by learners, use of hierarchical analyses, emphasis on the structure and organization of knowledge, and linking new knowledge to learners' prior cognitive structures (Ertmer & Newby, 1993). Therefore, learning is no longer simply the acquisition of behaviors, but also includes storing knowledge about relations in the world, and acquiring structural representations and mental models (Graeme, 1995). Finally, Zahorik (1995) list five elements that need to be taken into account for knowledge acquisition to be successful. They include activating knowledge, where prior knowledge structures are utilized;

acquiring knowledge, where knowledge is acquired in wholes; understanding knowledge, with thorough examination; using knowledge, extending and refining structures; and reflecting on knowledge.

For optimal acquisition, new knowledge should be presented in a form that can be linked to old knowledge. Knowledge can then be assembled in a hierarchical form called schemata. Schemas are basic structures for organizing information and concepts. They are links between discrete chunks of information organized in a categorical form. Therefore, by activating a superordinate body of knowledge, subordinate information can be attached. This learning strategy process is analogous to standard computer functions and even more closely resembles the workings of an Internet WebPages. Homepages or the starting page are presented and displays various links or commands which will take the user to other pages, which contain associative information. In this way, the user or learner can begin with the foundation information and build on it as they progress through the links of information, integrating pieces of information into their useful schema for future use.

Retention

Retention is typically defined as the ability to remember, whereas retrieval is the process of searching for and finding information in long-term memory. Retention requires coding and transforming modeled information for storage in memory, as well as cognitively organizing and rehearsing information. Retention is increased by rehearsing information to be learned, coding in visual and symbolic form, and relating new material to

information previously stored in memory. Knowledge retention is typically measured by performance on paper-and-pencil tests (Halpin & Halpin, 1982).

Evidence from Semb and Ellis (1994) indicates that long-term retention for knowledge taught in schools is substantial. They have made several points including retention decreases over time as a function of length of the retention interval; forgetting curves do not decline as rapidly; increasing the level of original learning differentially affects retention performance; both instructional content and assessment tasks affect learning and retention; most instructional strategies that promote higher levels of original learning may result in better retention; and higher ability students learn and remember more than lower ability students, although forgetting is about the same. They also report that the more prior knowledge or experiences that the student has of the specific concept, the more likely they will be able to retrieve the associated information. Very few students enter a classroom with no prior knowledge of the subject matter to be taught. This situation presents a problem for measuring both original learning and retention. While we focus on knowledge taught in school, we recognize that some learning has occurred prior to schooling and may occur during school outside the classroom, informally (Semb & Ellis, 1994). This aspect, although frequently overlooked, is critical in both sustaining formal education and realizing the power of learning which takes place through informal settings at home or in a museum.

Other factors which may influence the amount of retention and the rate are recall strategies such as chunking, where individual bits of data are grouped into meaningful larger units, typically in groups of seven, or special circumstances such as with episodic memory, where long-term memory for information is tied to a particular time and place,

especially memory of the events in a person's life. These become increasingly important as the learner struggles to maintain large amounts of educational information throughout their scholastic growth.

Learning Strategies

Bruner (1966) states that a theory for learning should address four major aspects: (1) predisposition towards learning, (2) structured so that it can be readily grasped by the learner, (3) an effective sequence to present the material, and (4) the nature and pacing of reinforcements. Good methods for structuring knowledge should result in simplifying, generating new propositions, and increasing the manipulation of information. Garner (1990) agrees that strategies enhance learning. However, learners often fail to invoke strategic behaviors due to five reasons, poor cognitive monitoring; primitive routines; meager knowledge base; attributions and classroom goals that do not support strategy use; and minimal transfer. If learners do not notice that they are not learning, they are unlikely to seek a strategic remedy (Glenberg, Wilkinson, & Epstein, 1982). This statement provides substantial support for the need of self-regulated learners.

Self Regulated Learning

One of the greatest difficulties facing designers of constructivist learning environments is the question of evaluating the learning that takes place. Under the constructivist paradigm, the learner determines his or her own learning goals. Given that the designers may not know the goals of the learner, how can they evaluate whether the goals have been met? The simplest answer seems to be to ask the learner. How does the

learner know whether they have met their own goals? If the learner is self-regulating, that is, if they are constantly, and consciously, monitoring their comprehension and correcting comprehension failures, they will know if they have met their goals. How then can the designer know whether the learner is self-regulating? This aspect typically requires additional measures. Because it is a complex cognitive event, which involves numerous activities for the learner, researchers have a difficult time measuring a self-regulation learner (Howard-Rose & Winne, 1993). Three scales which have attempted to quantify self-regulated learning (SRL) are the SRL Rating scale (Corno, & Collins 1983); The Learning and Study Strategies Inventory (LASSI) (Westerman, 1995); and The Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich & Garcia, 1993). The results show that the revised MSLQ metacognitive self-regulation scale seems to be a reliable and valid measure of self-regulated learning when given in a web based learning environment.

Self-regulated learning is a dualistic construct with properties of an aptitude (Snow & Lohman, 1984) and an event (Winne, 1997; Winne & Hadwin, 1997). Self-regulated learners are students whose academic learning abilities and self-discipline make learning easier so motivation is maintained. Albert Bandura (1977) studied observational learning (recall the modeling in the Bobo doll study) and self-regulation. Bandura defined self-regulation as the ability to control our own behavior and it is the workhorse of human personality. Bandura suggests three steps: (1) Self-observation, we look at ourselves, our behavior, and keep tabs on it; (2) Judgment, we compare what we see with a standard; (3) Self-response, if we did well in comparison with our standard, we give ourselves rewarding self-responses. If we did poorly, we give ourselves punishing self-responses.

According to Bandura's social cognitive theory, individuals possess a self-system that enables them to exercise a measure of control over their thoughts, feelings, motivation, and actions. This self-system encompasses one's cognitive and affective structures and provides reference mechanisms and a set of subfunctions for perceiving, regulating, and evaluating behavior, which results from the interplay between the system and environmental sources of influence. As such, it serves a self-regulatory function by providing individuals with the capability to influence their own cognitive processes and actions and thus alter their environments. Individuals engage in self-referent thought that mediates between knowledge and action. Through self-reflection, individuals evaluate their own experiences and thought processes. Bandura (1986) argued that self-reflection is the most uniquely human characteristic. Self-reflective judgments include perceptions of self-efficacy, beliefs in one's capability to organize and execute the courses of action required to manage prospective situations. The higher the sense of efficacy, the greater the effort, persistence, and resilience.

Bandura (1986) wrote that, through the process of self-reflection, individuals are able to evaluate their experiences and thought processes. According to this view, what people know, the skills they possess, or what they have previously accomplished are not always good predictors of subsequent attainments because the beliefs they hold about their capabilities powerfully influence the ways in which they will behave. However, self-perceptions of capabilities help determine what individuals do with the knowledge and skills they currently possess. More importantly, self-beliefs are critical determinants of how well knowledge is acquired initially.

In another study, Yang (1993) has found that with respect to self-regulatory learners: 1) high regulatory students tend to learn better under learner control than program control; 2) high self regulatory students are able to monitor, evaluate, or manage their learning effectively during learner controlled instruction with embedded questions; 3) learner control reduces instructional time required to complete the lesson; and 4) high self-regulatory students manage their learning and time efficiently. One procedure for supporting self-regulated learning is to instruct learners to engage in self-explaining, a behavior associated with enhanced learning, that ordinarily follows from spontaneous self-monitoring (Chi et al., 1994). Learning in informal settings is an ideal environment where activities create opportunities for students to practice scientific inquiry, and to do so in a self-directed fashion where learners take responsibility of their own learning (Gunstone, 1991). Successful learners tend to assess their own understandings and monitor their own progress in ways that seem to facilitate learning (Chi & Bassok, 1989). In other words, one must know what they do not know in order to ask the questions that promote learning (Miyake & Norman, 1979). This suggests the importance of prior knowledge before a concept is introduced or attending an informal learning environment in order to determine the quantity and quality of information which the learner has not already incorporated in their personal schema of knowledge.

In addition, Hagen and Weinstein (1995) believe that master and performance goals can dramatically include college students' self-regulated learning. These independent but complementary types of goals are shaped in important ways by how faculty organize and structure their classrooms for learning. Involvement in self-regulatory learning is tied closely to student efficacy beliefs (Pintrich & DeGroot, 1990).

In presenting a model of self-efficacy as a temporally preceding of self-regulated learning (defined as behavioral constellation of monitoring, elaboration, and effort management strategies), Garcia and Pintrich (1991) determined that a participant's belief in their capabilities was more likely to lead to higher levels of self-regulated learning. They developed the Motivated Strategies for Learning Questionnaire, which indicated that intrinsic motivation and self-efficacy had substantial effects on self-regulated learning. In another study, Garcia and Pintrich (1992) have shown that metacognitive self-regulatory strategies were consistently positively related to critical thinking across domains. The study supports the positive relationship between motivation, deep strategy use, and critical thinking. Pintrich (1995) has found that self-regulated learning is an important component of learning for college students. Students must have greater awareness of their own behavior, motivation, cognition and their positive motivational beliefs, and must practice self-regulated learning strategies. Corno and Mandinach (1983) define self-regulatory learning as an effort to deepen and manipulate the associative network in a particular area and to monitor and improve that deepening process. It refers to the deliberate planning and monitoring of the cognitive and affective processes that are involved in the successful completion of academic tasks. They also suggest that for some learners these metacognitive processes of planning and monitoring may be so well developed that at times they appear to occur automatically. Five components are viewed by Corno and Mandinach (1983) as necessary and sufficient to define self-regulated learning. The five components are organized into two categories: the information acquisition processes that include alertness (receiving and tracking information), and monitoring; and the transformational processes of selectivity, connectivity, and planning. They continue to

state that self-regulated learning, which represents the highest form of cognitive engagement, is epitomized by the task appropriate use of information acquisition and transformation skills. Corno (1994) investigated the development of students' orientations to engage in self-regulatory effort and to value or even enjoy this experience. The conclusion is that self-regulated learning comes about from the continuing interchange between students and the educating elements of their extended environments (such as in informal settings), adults and knowledgeable peers, various enacting curricula, and affording activities. Winne (1997) suggests that learners experiment, bootstrapping newer forms of self-regulated learning from prior forms and enabling the learner to step back and review or reflect on their acquisition.

Self-conscious reflection is a perspective of self-regulation that involves evaluation and modification of the goal or objective, as well as design of the path or procedures used to get there. Learning requires self-conscious reflection. Functionally, this is the best approach. This type of learning requires evaluating and choosing between two or more viable alternative paths.

Zimmerman (1989) defines self-regulated learning strategies as actions and processes directed at acquiring information or skill that involve agency, purpose, and instrumentality perceptions by learners. Strategies include self evaluation, organizing and transforming, goal-setting and planning, seeking information, keeping records and monitoring, environmental structuring, self consequating, rehearsing and memorizing, seeking social assistance, and reviewing records. Subskills required to organize a course of action are themselves governed by broader self-regulatory skills such as knowing how to diagnose task demands or constructing and evaluating alternative strategies. Self-

regulated learning is not a mental ability, such as intelligence, or an academic skill, such as reading proficiency; rather, it is the self-directive process through which learners transform their mental abilities into academic skills (Schunk & Zimmerman, 1998). Possessing these self-regulatory skills can permit students to improve their performances across varied academic activities. He has also developed a cyclic model, which represents the behaviors of a self-regulated learner (figure 2-2).

Figure 2-2. Cyclic Model of Self-Regulated Learning (Zimmerman, 1996).

1. Self-evaluation and monitoring occur when students judge their personal effectiveness, often from observations and recordings of prior performances and outcomes.

2. Goal setting and strategic planning occur when students analyze the learning task, set specific learning goals, and plan or refine the strategy to attain the goal.

3. Strategy-implementation monitoring occurs when students try to execute a strategy in structured contexts to monitor their accuracy in implementing it.

4. Strategic-outcome monitoring occurs when students focus their attention on links between learning outcomes and strategic process to determine effectiveness.

The model is cyclical because self-monitoring on each learning trial provides information that can change subsequent goals, strategies or performance efforts. An important part of this model is initial self-evaluation, because this typically initiates the learner's attitude toward belief in his or her own competence, or self-efficacy.

Zimmerman and his associates have been instrumental in tracing the relationships among self-efficacy perceptions, self-efficacy for self-regulation, academic self-regulatory processes, and academic achievement. This line of inquiry has successfully demonstrated that self-regulatory efficacy contributes to academic efficacy. Self-efficacy is a critical component of self-regulated learning theory. Self-efficacy is a person's sense of being able to deal effectively with a particular task; a belief about personal competence in a particular situation. If an individual student believes they are capable of learning the concept or regulating their own acquisition of the knowledge, then their ability to learn will increase. Schunk and Zimmerman (1998) indicate that this factor provides a bridge between the cognitive and the contextual forces, such as informal settings, by way of increasing self-regulatory learning. Zimmerman, Bandura, and Martinez-Pons (1992) used path analysis to demonstrate that academic self-efficacy mediated the influence of self-efficacy for self-regulated learning on academic achievement. Academic self-efficacy influenced achievement directly as well as indirectly by raising students' grade goals. Results of these investigations demonstrate that acquisition of cognitive skills, modeling effects, attributional feedback, and goal setting influence the development of self-efficacy beliefs and that these beliefs, in turn, influence academic performances.

Schunk's (1990) definition of self-regulated learning includes the beliefs that learners hold with respect to their capabilities for learning (self-efficacy). It is Schunk's view that self-efficacy, as a predictor of motivation and skill acquisition, can help explain students' self-regulated learning efforts (Schunk, 1988). Students who attribute successes to their abilities and efforts are likely to feel efficacious about learning and engage in self-regulatory behaviors that further increase their skills (Schunk, 1990).

As far as tools for assisting self-regulated learning, there are several characteristics of computer technology that make it a desirable vehicle for examining the concept. Computers make it possible to independently store data collected via interaction with the student, thus providing the possibility for improved efficiency in data collection process. Computers also have the capability of monitoring and recording user interaction and/or progress providing immediate feedback to the learner. This capability has both research and instructional benefits: first, profiles of the step-by-step process of learner interaction with ideas or concepts can be stored and retrieved for later analysis; second, the immediate feedback that the learner receives allows a greater degree of learner control by providing individualized opportunities for review of the material. Mandinach (1984, 1987) has used the computer as a vehicle for studying the concept of self-regulated learning in the strategic planning knowledge of self-regulation in intellectual computer games. Mandinach concluded that the high and low ability students displayed different patterns of cognitive engagement and the those who utilized self-regulated learning, task focus, and resource management forms of engagement were more successful in completing the game.

At this point, little is known about self-regulatory or self-reflective learning in informal educational settings. Winne (1993) admits that little is known about instructional

design issues that affect student's learning with technology. Weinstein (1996) agrees that relatively little is currently known about the development or acquisition of self-regulation and what can be done to facilitate its development with new technology. Concerns such as what influence can different self-monitoring strategies, learning tools, and physical and social arrangements exert on student learning when students use them before, during, and after they use the resources of an informal setting require further study.

Learning Approaches

Two types of learning approaches typical of instruction settings and often seen in informal settings are free choice or constructivism and structured or objectivisim.

Free Choice - Constructivism

Free choice learning places the responsibility for learning on the learner. They are typically considered to be synonymous to informal learning settings such as museums, aquariums and science centers. Basically, a free choice environment allows the learner to select what and how they are to attend and acquire information. Potential positive attributes are similar to benefits from learning in an informal setting, in addition to possible increase in longer concept retention due to increased learner control. A free choice learning setting resembles a constructivist approach in that it allows the learner to build upon their prior experiences at their own pace and in their own particular direction of interest and perspective. A true constructivist environment in Cyberspace would allow the user to access any and all areas of the Internet. However, for this study, a constructivist

environment has been operationally defined as one, which allows the participant to access several internal links to build their knowledge of the subject.

Perhaps the first constructivist philosopher, Giambatista Vico commented in a treatise in 1710 that one only knows something if one can explain it (Yager, 1991). Immanual Kant (18th century) further elaborated this idea by asserting that human beings are not passive recipients of information. Learners actively take knowledge, connect it to previously assimilated knowledge and make it theirs by constructing their own interpretation (Cheek, 1992). Inferences, elaboration's and relationships between old perceptions and new ideas must be personally drawn by the student in order for the new idea to become an integrated, useful part of their memory. The learner must actively construct new information onto their existing framework for meaningful learning to occur.

Although constructivist theory has become popular in recent years, the idea of constructivism is not new. Aspects of the constructivist theory can be found among the works of Socrates, Plato, and Aristotle (ranging from 470-320 BC), all of which speak of the formation of knowledge. Saint Augustine (mid 300's AD) taught that in the search for truth, people must depend upon sensory experience. This of course left him out of balance with the church. More recent philosophers such as John Locke (17th to 18th centuries) taught that no man's knowledge can go beyond his experience. Kant (late 18th to early 19th centuries) explained that the logical analysis of actions and objects lead to the growth of knowledge and the view that one's individual experiences generate new knowledge (Brooks & Brooks, 1993). Although the main philosophy of constructivism is generally credited to Jean Piaget (1896-1980), Henrich Pestalozzi (1746-1827), also from Switzerland, came to many similar conclusions over a century earlier.

Pestalozzi maintained that the educational process should be based on the natural development of the child and his or her sensory influences. Pestalozzi's basic pedagogical innovation was his insistence that children learn through the senses rather than with words. He labeled rote learning as mindless, and he emphasized instead linking the curriculum to children's experiences in their homes and family lives (Fabricius, 1983). Manges and Wigle (1997) believe that through constructivist teaching, students can tap into their natural learning potential because their experiences, their prior knowledge, and their personal interpretations become essential components of all classroom activities.

However, Piaget provided the foundation for modern day constructivism and it's hybridization. In Piaget's view, intelligence consists of two interrelated processes, organization and adaptation. People organize their thoughts so that they make sense, separating the more important thoughts from the less important ones, as well as connecting one idea to another. At the same time, people adapt their thinking to include new ideas, as new experiences provide additional information. This adaptation occurs in two ways, through assimilation and accommodation. In the former process, new information is simply added to the cognitive organization already there. In the latter, the intellectual organization has to change somewhat to adjust to the new idea (Berger, 1978).

Constructivist theory in education actually is a branch of neo-Piagetian thought, which is rooted in personal constructivism (Novak, 1977; von Glasersfeld, 1989). Soloman (1987), Millar (1989), and Cobern (1993) have taken personal constructivism and have paved a way for contextual constructivism. Contextual constructivism is defined by how the learner interprets phenomena and internalizes these interpretations in terms of their previous experience and culture.

The basic idea of constructivism is that the learner must construct knowledge, the teacher cannot supply it (Bringuier, 1980). This is vividly expressed by the Farsi proverb, a well must produce its own water. The constructivist approach is a view that emphasizes the active role of the learner in building understanding and making sense of information. Constructivist approaches to learning assume that subjectivity is critical because learners take in information and process it in unique ways that reflect their needs, dispositions, attitudes, beliefs, and feelings. Constructivism espouses creating meaning from experience (Jonassen, 1991). Constructivism stresses the interaction between learner and the environment and learning is embedded in the context in which it occurs. Thereby learners are encouraged to develop their own understanding of knowledge. Brooks and Brooks (1993) state that constructivism is not a theory about teaching. It is a theory about knowledge and learning that process and learning occurs daily and relentlessly in classrooms. It is a philosophy that encompasses knowledge, learning and thinking. They have compiled a list of characteristics of a constructivist teacher that include encouragement of student autonomy; utilization of manipulative, interactive and physical materials; use of cognitive terminology such as classify, analyze, and create; inquiry understanding; encourage engagement of dialogue; ask open-ended questions; pursue elaboration of student responses; provide time for students to construct relationships and create metaphors; nurture students through frequent use of the learning cycle method. Inquiry learning is an approach in which the teacher presents a puzzling situation and students solve the problem by gathering data and testing their conclusions.

Brandt (1992) has determined a similar list for a constructivist approach, engage students in authentic tasks, assist students with producing knowledge bases that promote the

application of information, and diversity of thought; build learning communities linking students and promote substantial, applicable learning rather than mere credentialing. Students who plan to get through a course by regurgitating content also resist learning independently; they are probably not interested in developing critical thinking or problem-solving skills.

Von Glasersfeld (1995) argues that knowledge and reality do not have an objective or absolute value or, at the least, that we have no way of knowing this reality. He indicated in relation to the concept of reality, that it is made up of the network of things and relationships that we rely on in our living, and on which, we ultimately believe in. Rather than thinking of truth in terms of a match to reality, von Glaserfeld focuses instead on the notion of viability. To the constructivist, concepts, models, and theories are viable in they prove adequate in the contexts in which they were created. As to the role of the instructor, von Glaserfeld (1996) indicates that their role is not to dispense knowledge but to provide students with opportunities and incentives to build it up. Mayer (1996) describes teachers as guides, and learners as sense makers. In Gergen's (1995) view, teachers are coordinators, facilitators, resource advisors, tutors or coaches.

With respect to learning, von Glaserfeld (1995) argues that from the constructivist perspective, learning is not a stimulus-response phenomenon. It requires self-regulation and the building of conceptual structures through reflection, abstraction and an integrated thought process. It is reasonably easy to learn something that matches or extends an existing mental model that we may possess. This principle states that mental models are not only the way that we organize our interactions with the world, but they also control how we incorporate new information and experiences (Bransford & Johnson, 1972).

Rather than behaviors or skills as the goal of instruction, concept development and deep understanding are the foci. In this paradigm, learning emphasizes the process and not the product. How one arrives at a particular answer, and not the retrieval of an objectively ~~true~~ solution, is what is important. Learning is a process of constructing meaningful representations of making sense of one's experiential world. These models derive their validity not from their accuracy in describing the world, but from the accuracy of any predictions which might be based on them (Hanley, 1994).

Zahorik (1995) believes the constructivist model is best suited for situations when goals are for students to use higher-order (critical) thinking skills, to understand the cause or effects of ideas or actions, and to become fully engaged in their learning. Zahorik (1995) asserts that knowledge is constructed by humans; not a set of facts; conjectural and fallible; grows through exposure; and is created or constructed by humans as they attempt to bring meaning to their experiences and can never be stable.

There are three types of constructivism according to their different points of view.

1. Radical constructivism emphasis subjectivity or the absolute impossibility of being objective and, in the extreme, even a rejection of realism (Goodman, 1984; Molenda, 1991). The center of the whole learning process, students are given the freedom, as well as the responsibility, to decide what and how to learn (Perkins, 1991).
2. Moderate constructivism acknowledges that there is a realism in which there are enough spaces for people to construct their own understanding of the world (Cognition and Technology Group at Vanderbilt, 1991). They believe that knowledge is a dialectical process, the essence of which is that individuals have opportunities to test their

constructed ideas on others, persuade others of the virtue of their thinking, and be persuaded (Cognition and Technology Group at Vanderbilt, 1991).

3. Rational constructivism recognizes the dynamic nature of learning or the mediation of new knowledge by old during the interpretation-reflection process (Winn, 1991). What distinguishes them from the radical and moderate constructivists is their recognition of the dynamic nature of learning, the impossibility of predicting how students will learn, the understanding that knowledge is an ever-changing process, and the weakness of being anti- empirical in human cognition (Cognition and Technology Group at Vanderbilt, 1991).

One particular research study in support of constructivist teaching was performed by Caprio (1994). In the study, the constructivist approach was employed and compared to the traditional lecture format for the second semester of a two-semester anatomy and physiology sequence in a community college. The two student groups were matched for academic ability and prerequisites. Both courses were night classes and most of the students were hoping to major in health-career programs. The testing instrument was the first exam. The same exam was given to both sets of students at midterm. A drawback to the study was that the two groups were studied seven years apart. The results showed that students taught by the constructivist methodology obtained better exam grades. The average exam score for the constructivist group was 69.7% (n=44) while that taught by the traditional lecture method was 60.8 % (n=40). A t-Test showed that the grade difference was significant ($p > 0.99$). In support of this study, Lord (1997) compared student learning in two sections of an introductory college biology course. Groups were taught in the traditional teacher-centered, lecture/laboratory format (n=86), and in a

student-centered constructivist format (n=98). The latter group performed significantly better on the same tests, maintained a better attitude throughout, and through a post-test survey, enjoyed the course more.

However, a study by Chang (1994) compared a constructivist approach to an objectivist approach to teaching chemistry in a junior high school class provided different results. Students in the constructivist student-centered approach produced much higher explanation scores than students in the conventional approach. However, students in the constructivist approach did not perform significantly higher than students in the conventional treatment on multiple choice scores; and they did not produce higher scores in higher-level questions (non-recall). A retention test revealed that regardless of the teaching strategy, no student performance differences persisted two weeks after instruction.

Carey et al. (1981) probed the nature of student views on scientific inquiry. Despite instruction in the scientific method in the traditional mode, many students do not understand the nature or purpose of scientific inquiry. Science is seen as a random activity that has little meaning in real life. Students were rated by interviews on a scale of one to three about their conception of how science is investigated before and after a constructivist style learning unit on the topic. Prior to the unit, most students fell in the Level one category. Level one students view science as a way of understanding facts about the world. After the learning unit, most of the students had moved to a Level two understanding; they saw scientific inquiry as being guided by questions and ideas. They also understood the difference between an idea and an experiment. Only a few students achieved level three understanding. At this level, the student understands the cyclic,

cumulative nature of science and recognizes the goal of science as the construction of deeper explanations of the universe.

One specific feature of constructivist philosophy directly relates to learning in informal settings. The notion of experimentation or exploration is valuable forms of learning (Daiute, 1989; Garvey, 1977; Herron & Sutton-Smith, 1971). Exploration involves the consideration of novel combinations of ideas, and the hypothetical outcomes of imagined situations and events. It is a form of mental exploration in which children create, reflect on, and work out their understanding. Actual experimentation, the manipulation and testing of ideas in reality, provides learners with direct, concrete feedback about the accuracy of their ideas as they work them out. Experimentation and exploration are self-structured and self-motivated processes of learning. Both encourage the learner to reflect on ideas in ways generally not promoted by current school curricula.

Another approach to pedagogy, but more specifically related to science education is Saunders' (1992) approach. Saunders (1992) states that in being a constructivist in science education does have implications and that the implications lead to a certain approach to teaching science. His first step is to organize hands-on investigative labs. These are problem centered and differ from the traditional recipe labs in that there are no prescribed methods or procedures to solving the problem or exploring the phenomena. Saunders (1992) states that in using the inquiry approach the students must utilize their own schema to formulate expectations about what is likely to be observed. Another implication is that there is active cognitive involvement. This is in contrast to the passive learning that takes place in many teacher centered classrooms. Saunders (1992) explains that learning is made meaningful through activities like thinking out loud, developing

alternative explanations, interpreting data, participating in cognitive conflict (constructive arguing about phenomena under study), development of alternative hypothesis, the design of further experiments to test alternative hypothesis, and the selection of plausible hypotheses from among completing explanations.

Constructivism in the undefined limits of virtual space (informal setting) frees pedagogy. Virtual space enables: faculty drawn from anywhere in the world, linked by Internet resources, thereby encouraging an endless array of multicultural learning environments (Winn, 1991).

The bottom line is that constructivism is philosophy that views the student as a thinker, creator, and constructor of knowledge. This is certainly a change from a traditional view of a student as an owner of knowledge.

Structured - Objectivism

Briggs (1967) defined structure as meaning the description of the dependent and independent relationships among component competencies, arranged so as to imply when sequencing can be random or optional and when sequencing must be carefully planned, on the basis that transfer will be optimal in order to build up from simple skills to more complex ones.

Educationally, structure and sequence serve a number of purposes that include the design of instruction (Reigeluth, Merrill, & Bunderson, 1978). In museums, these considerations should encompass the design and placement of exhibits, adjunct material, and other related activities such as tours, classes, etc. Ellis (1993) found that exhibit sequencing in museums can enhance visitor acquisition of cognitive and affective

information. Visitors who are informed about the structure and sequence within an exhibit may invest greater energy than if they perceived it as having no real structure or sequence (Salomon, 1983).

Objectivists believe that knowledge is outside of the learner, truths exist and learners must memorize them. The objectivist model is best seen in behaviorist methodology such as in direct instruction, where the goal is usually to have the student acquire and repeat factual information. According to the objectivist view, objects have intrinsic meaning, and knowledge is a reflection of a correspondence to reality. In this tradition, knowledge should represent a real world that is thought of as existing, separate and independent of the knower; and this knowledge should be considered true only if it correctly reflects that independent world. Jonassen (1991) summarizes objectivism: Knowledge is stable because the essential properties of objects are knowable and relatively unchanging. The important metaphysical assumption of objectivism is that the world is real, it is structured, and that structure can be modeled for the learner. Objectivism holds that the purpose of the mind is to mirror that reality and its structure through thought processes that are analyzable and decomposable.

Objectivism holds that the world is completely and correctly structured in terms of entities, properties, and relations (Duffy & Jonassen, 1991), and that knowledge is stable, staying independent of the individual because the essential properties of objects are knowable and relatively unchanging. It assumes that people can gain the same understanding, and this understanding can be completed when rational or systematic rules are used to draw conclusions (Winograd & Flores, 1986).

The objectivist model has resulted in somewhat of a stereotyped portrayal of teaching and learning which is widely criticized and often evoked as the target of educational reform. The idea that there is a fixed world of knowledge which the student must come to know is common to an objectivist. Information is divided into parts and built into a whole concept. Teachers serve as pipelines and seek to transfer their thoughts and meaning to the passive student. There is little room for student-initiated questions, independent thought or interaction between students.

Learning Settings

Informal Learning Settings

Many educators call for more doing and less talking in our educational system. Jean Piaget (1974) and many of his students have shown the importance of direct experience for students in learning, especially in learning the concepts of science, and for young children (Elkind, 1976). Nearly the whole of our knowledge about the natural world has come form investigators who had direct experiences with phenomena of natural science outside of the formal classroom (Keown, 1986). There is no classroom equivalent to observing a river--clean, clear and healthy as it enters a city--and later to find it green and oxygen deficient with the community of pollution organisms as it leaves the city. These informal settings are where encounters occur that engages all of the students' senses.

Informal settings are typically places where learning takes place in museums, zoos, aquaria, science and technology centers, homes, and clubs. They are also characterized where motivation is internal, the content is variable and possibly unsequenced, attendance

is voluntary, displays and objects are provided, learners are of all ages, and there is more diversity in the learners' backgrounds.

The modern museum with its manipulative exhibits and free-choice format invites visitors to explore by looking, touching, manipulating, experimenting, and hopefully thinking. As informal educational institutions, museums and science centers can do more than entertain and amaze visitors. If exhibits are designed correctly, they can attract and hold the attention of visitors long enough so that they become engaged with the information and learn from them. Millions of people visit museums every year. For various reasons, they seek these experiences out and appear to be intrinsically motivated once there. A considerable amount of sensory stimulation, learning, and affect appears to be influenced in these "free-choice" settings (Koran, Longino, & Shafer, 1983).

Informal settings are ideal for introducing, enhancing and incorporating new and novel ideas into previously developed schema. However, one of the criticisms for informal learning environments, such as museums, is the lack of focus for young learners and the tendency for realizing only the fun aspect and overlooking the educational benefits. Therefore, many of the attributes that increase the power of informal settings could also be seen as their weakness. Attention is captured, but substantial learning may not be the outcome; knowledge acquisition could result, but reconciliation of prior knowledge and new experiences may not occur. The self-guided/self-reflective advantage of this type of learning setting could be detrimental to the non-regulated learner or a poorly constructed informal setting. Especially, if they had been enticed with promises of amusement and entertainment as the primary goal. Science is a great intellectual

adventure and can be fulfilling as well as enjoyable in these settings. At the very least, exhibits in such settings may capture student's attention and enhance their intrinsic interest in science learning which could lead to further engagement (Friedman, 1995). Johnson and Butts (1983) found that engaged time measures were significantly related to achievement, which indicates an instructor should endeavor to keep the students as engaged as possible. Students who are engaged or pay attention or perceived they are engaged or paying attention during lecture classes achieve more than students who are observed as nonengaged do.

For many years, attention has been known to be a critical factor in visitor learning in informal settings such as museums (Wittlin, 1968; Shettel, 1973; Koran, Koran & Longino, 1986; Koran, Koran & Foster, 1989). Many have observed that in order for an exhibit to be educationally effective it must attract viewer attention, maintain attention, and provide useful information. Hands on activities have been shown to attract attention and holding power (Koran, Morrison, Lehman & Koran, 1984). Questions inserted into text materials have been shown to converge attention on specific content, when they precede the content, and to produce divergent memory search, when they follow the content. Acquisition and retention of specific kinds of information results (Rothkopf, 1970). For a learner with higher expectations, attempting to be self-reflective while attending could be advantageous to their personal knowledge acquisition.

Roschelle (1995) states that informal learning setting such as hands-on science centers can provide students with open-ended challenging activities that can provide a context for complex thinking and reasoning, thereby promoting the integration of prior knowledge with new information and experience.

Falk and Dierking's (1992) model suggested that visitors construct their own unique meaning for the visit experience according to personal background and interaction with the social and physical environment. Memories are persistent in the minds of children and remain with them into adulthood. Falk and Dierking (1994) interviewed middle school children and graduating college students and found that 80% of them were able to recall three or more specific things linked to a field trip (informal setting) during their first, second or third grade. Balling and Falk (1980) found that children familiar with a setting tend to learn more than children who are not do. It is clear that students' prior knowledge is important in determining how they interact and what they learn from exhibits in informal settings (Beiers & McRobbie, 1992; Falk, Koran, & Dierking, 1986; Gottfried, 1979). Falk (1983) found that both the time spent at an exhibit and the nature of the interaction affect the amount of learning which occurs. Falk also indicates that time in informal settings is a measure of constraints, needs, and values. Therefore, time is the most frequent measure used for evaluating exhibit's quality/effectiveness and assessing visitor behavior. Interaction with exhibits is most effective when learner's thought processes match those required to understand the exhibit (Boram & Mark, 1991; Feher & Rice, 1985; Javlekar, 1989; Tuckey, 1992). An important aspect of structure is the means by which students are cued to salient features of the exhibits. The most universal cue is the labeling, or signage of the exhibit, which Screven (1986) discusses at length. Koran and Koran (1986) suggested that besides learning, curiosity, psychomotor development, interest, appreciation, motivation, and generalization all could be considered among the desired outcomes of a visit to an informal setting such as a museum.

Serrell (1997) indicates that tracking and timing data suggest that visitor's go where they want to go (in informal settings). They skip elements, visit only one-third of them, and spend much less time (typically less than 20 minutes) than often assumed. She also points out concerns for effective communication of didactic objectives. These include when the exhibits require extensive label reading, the majority of visitors will not be able to understand them; when the exhibit contains unnecessary sections, visitors will become confused; however, if the exhibition is clear and concise, high time and high use will not be necessary for understanding.

Falk (1983) compares museums to department stores and museum visitors are like shoppers. In a store, a customer's monetary resources determine behavior; in a museum, time plays the comparable role. There are serious shoppers who know exactly what they wish to buy, just as visitors who know just what they want to view. There are also window shoppers who never buy anything, bring a social partner and may become "impulse buyers". In the same token, window shopper museum visitors casually stroll into the informal setting and leisurely stroll by exhibits with minimal holding time, engagement, attention and therefore learning. In the same analogy, similar learners can be identified using the Internet as an informal setting. However, as anyone who has experienced surfing the net, it can capture the attention of the best intended window shopper. Even for the serious shopper who only wishes to get in the system, obtain that one piece of information and log out, finds themselves distracted onto a plethora of possibilities which are presented during the simplest of searches. To minimize this phenomenon for the learner, a focus vehicle is required. This may be in the form of available software, time

limitations, oversight, or more likely limited access to the World Wide Web (WWW) through internal or intent networking capabilities.

Internet, WWW Pages and Cyberspace

There is a cultural shift from the importance of possessing knowledge in one's own memory to be able to effectively search for and use the information needed for particular purposes. Therefore, it becomes increasingly important for the individual to possess some knowledge of computer technology. Undoubtedly, the individual would be greatly advantaged if they could gain this knowledge at an early age, perhaps as a student. There can be little doubt about the advantages the computer possesses over any textbook as a tool for learning. Firstly, the student is able to access a vastly more superior range of information from the computer, as too is the teacher. Available computer programs, such as the Internet, provide an excellent opportunity to access an astronomical quantity of information. In fact, the Internet provides greater access to a larger bank of knowledge for teachers and it enhances the quality and quantity of information that teachers provide for their students. The teacher as the primary source of knowledge no longer suffices in a world where knowledge doubles every seven years and 10,000 scientific articles are published every year (Forman, 1987). The Internet is highly valuable as a resource tool for education. Moersch (1997) has described levels of technology implementation (LoTi), an instrument to measure the degree to which computers are used to support concept-based or process-based instruction, consequential learning, and higher order thinking skills in the classroom.

At present, computers in schools could be better conceptualized as a source of energy. The energy metaphor is applied to three categories of functions associated with computers in school: curriculum functions, teaching functions, and learning functions (Scriven, 1989). Juliano (1997) discusses the computer environment in terms of power pedagogy, which refers to any set of instructional methods designed to increase faculty productivity and to accommodate more students with existing facilities. It is a mechanism to use the WWW to supplement traditional instruction, focusing on use of the WWW as an intent teaching tool that establishes an extension in the regular classroom. Forman (1987) indicates that technology adds the ability for students to choose how, when, and where they participate in the learning experience and to bring together a vast wealth of previously unavailable learning resources.

There are several reasons why educators, administrators, and parents should support the use of the Internet in schools: equity, an infinite resource, students as active participants, self-motivation, student inquiry, assessing and improving student progress. On-line education provides the flexibility and efficiency of computer-assisted instruction as well as the individual attention of instructor-guided instruction (Huang, 1997). Berge (1997) discusses the advantages of on-line instruction in terms of meaningfulness, open communication, organized essential ideas, learning aids, modeling, active appropriate practice, pleasant conditions and consistency. Results also show that on-line use can increase student performance (Follansbee, 1997). Technology can help some people to participate more easily in education, to learn more effectively, and to enjoy learning more (Palmieri, 1997). Palmieri also realizes that technology will continue to be important in education because it will allow learners to access knowledge in their homes, in their

workplaces, (informal settings), at times in which they want to learn. Although Conlon (1997) warns that technology enthusiasts and politicians portray the Internet in unrealistic and misleading ways that inflate its suitability for school education. The Internet is not a library, community or panacea for difficult problems of teaching and learning. Determining the benefits and pitfalls for education requires extensive research and evaluation of the Internet and its alternatives. Saunders-McMaster (1997) points out one alternative in the Internet 2 project currently being developed by research universities and affiliate members to accelerate Internet development for higher education with the next generation of communications and technologies. Goodman (1997) describes the importance of learning to connect separate university of knowledge into a coherent whole. It is a mistake to emphasize connecting schools to the Internet without considering the kinds of thinking processes students need in order to learn from the information they access.

The nonlinear organization of text and graphics on the WWW allows greater user control. However, materials must be structured coherently by establishing associative and conceptual links without eliminating multiple pathways. A constructivist approach permits clear mental representation of concepts and the freedom for each learner to explore them (O'Carroll, 1997). Tillman (1997) has provided recommendations for applying hypermedia research to educational theory for WWW homepage design. Each destination should be able to stand alone; incorporate appropriate metaphor; provide visual clues indicating users' selections are being processed; include graphic or text-based organizers; include comparative, casual, sequential, associative, exemplary, and componential links; employ labeled and unlabeled links; and use multiple complementary stimuli.

Using the Internet in the context of the classroom is advantageous to both teachers and students. Teachers benefit from the wealth of resources available on the Internet and children benefit from further communication with the world around them and resources developed especially for their needs. In a sense, the Internet can be seen as collaborative teamwork, in that teachers publish their work and it is pooled with other teacher's work from around the world hence being an invaluable resource. Through the Internet students are better able to experience first hand other cultures in the world. There are, however, a number of disadvantages of using the Internet in the context of the classroom. Such disadvantages include the loss of valuable teacher/student interaction. There needs to be some form of censorship which will prevent the students from gaining access to detrimental types of publication that are too easily obtainable within the Internet. The computer does not necessarily act as a facilitator for student learning, it merely acts as a resource. Computers are a valuable resource for learning. It has been reported (Comber, 1997) that children using computers focused on tasks for longer periods; found previously boring tasks more interesting; were more eager to participate in and contribute to discussions; asked more questions; and improved their use of the standard conventions of print.

There is substantial evidence to suggest that the computer also offers the advantage of making work more stimulating, thereby motivating the individual. The search for information is made considerably easier, thus making one's workload less tedious, and perhaps more interesting. It is possible the difference in types of computer software can be used to motivate various kinds of students. Poorly motivated students may be so due to lack of understanding or interest. If appropriate software is used, they

may be enticed with the sheer novelty, the implied prestige of using a computer and the benefits of drill and practice of tutorials they are able to work through at their own pace. On the other hand, highly motivated students or students who know how to use computers well can be directed to enrichment coursework which is mind-provoking, features games and avenues of learning how to create through the medium of the computer.

The Internet is a valuable resource for teachers and students alike. When it is used in conjunction with other classroom practices, it is a valuable technological tool that furthers education in today's world. Like all classroom practices it has its advantages and disadvantages. Computers allow students to become self-regulated learners and with further training for both teachers and students, the Internet will have a big place in classrooms of the future.

Gender, Age, and Racial Identity

Gender, age, and racial identity have been found to have an effect on learners in general and user of electronic media, such included on the Internet. Wallace and Sinclair (1995) found female students to be more anxious and less confident with computers than male students. In another study, Comber (1997) found that in a survey of British secondary students, males reported significantly more experience with and positive attitudes toward computers than did females; younger students had significantly more experience and positive attitudes than older students did. Durndell (1995) surveyed Scottish secondary students and found that females were less experienced with computers at school, but played computer games as much as males; males were more likely to own

and use computers outside of a formal school setting. Also, males had more positive attitudes and were more likely to have sex-stereotyped views about computer use; and older students were less enthusiastic about computers. According to a recent study, about 90% of current Web users are male, and 87% describe their race as white (Pitkow & Recker, 1994). Maurer (1994) has explored the correlation between age, gender and computer anxieties; generally older, female students are more anxious about computer experiences than younger, male students. Kay (1992) has examined gender relationships of computer attitudes and realized that it depends on various factors. These factors include what attitudes you are measuring; what skills you are assessing; what the computer is being used for; and what age group you are sampling. Morris (1989) developed a Computer Orientation Scale (COS) to determine the relationship between age, education and computer attitudes. Generally, younger, less educated individuals had poor attitudes about computers. Laguna and Babcock (1997) examined the construct of computer anxiety in young and older adults in the context of a computer-based cognitive assessment. Results indicate that older adults had significantly higher computer anxiety than younger adults, however the anxiety was unrelated to performance as measured by percent correct on the task. However, the anxiety was related to performance as measured by decision time. Comber, Colley, Hargreaves, and Dorn (1997) investigated the effects of age, gender and prior computer experience upon attitudes toward computers. Males from both two different age groups reported greater experience with and more positive attitudes toward computers than females. Younger pupils, both male and female, had greater experience with and more positive attitude toward computers than older pupils did. Polyakov and Korobeinikov (1996) examined age-specific features of

human training in two different groups. Results showed that 33% of the older participants succeeded in training compared to 73% of the younger participants, implying that the ability to train decreases with age. Whitley (1997) performed a meta-analysis of studies of gender differences in computer-related attitudes and behavior using 40,491 U.S. and Canadian participants found that males exhibited greater sex-role stereotyping of computers, higher computer self-efficacy, and more positive affect about computers than did females. Bernhard (1992) found that in spite of equivalent instruction, boys completed a significantly greater number of computer tasks than did girls. In addition, boys showed more stereotypic attitudes towards computers than did the girls. In a cross-cultural study, Collis and Williams (1987) found a significant difference between the attitudes of males and females regarding their perceptions of each other's computer abilities. Hatti and Fitzgerald (1987) found that more girls than boys disliked computers. Newton (1991) reports that in a survey conducted of fourth and fifth grade students, he found that only 22% of girls, but 56% of boys were likely to have a computer in their home. And similarly, Sutton (1991) reports that families of male students were more likely to own a computer than families of female students.

Simon (1996) presents several statistics, which represent the inequitable distribution of information in Cyberspace. In this, technophobes are relatively older, have negative attitudes towards computers in general, have had little exposure to them, and are female. National statistics in 1993 reveal that the highest percentage of computer usage by students at school occurs in grades' one through eight (68.9%), however, the same age bracket of students have the lowest usage of computers at home (24.7%).

Kominski (1988) provided statistical information on computer usage in the United States in 1984. The data show that over 15 million American adults owned home computers, but only 53% actually used them. About 8% of U.S. households or 7 million had a computer, and households with school age children were three times as likely to have one. Among adults, 63% of the men and 43% of the women used the computer if it was present at the house. Although African Americans were less likely to have home computers, children who did have them used them more than white children.

Aptitude-Treatment Interactions

Aptitude-treatment interactions (ATI) reflect the notion of tailoring instruction to important student characteristics. They refer to differences in student outcomes as a function of the interaction of instructional conditions with student characteristics. ATI research examines how individual differences in aptitudes predict students' responses to forms of instruction. The notion that instructional conditions affect student outcomes differently depending on students' attributes is intuitively plausible (Corno & Snow, 1986). For the purposes of ATI research, aptitude has been defined as any characteristic of the individual, which functions selectively with respect to learning; that is, which facilitates or interferes with learning from some designated instructional method (Cronbach & Snow, 1977). Cronbach and Snow (1977) indicated that although a wealth of evidence can be obtained from ATI, they also noted that the findings cannot be replicated and may not be reliable.

Individual differences among learners constitute an important class of variables for research on instruction. Their study has been of interest because measures of these

variables usually predict leaning outcomes. Practical interest for science educators stems from the possibility that such interactions may be used to adapt science instruction to fit different learners optimally (Koran & Koran, 1984).

While the educational research community has shown interest in ATI, the concept is not limited to these traditional settings. Just as the Darwinian view of natural selection operates to favor species with characteristics suited to a particular set of conditions, there are many circumstances whereby individuals excel with respect to their distinctive approaches. Learning via computers is no exception to this rule. Differences between young and old, male and female, racial cultures, aptitude, etc. have already been demonstrated in literature to provide various results. Therefore, ATI is based on the premise that there is no one best educational treatment for everyone and electronic media in education may act as a supplement to the overall curriculum program. The general approach of ATI research is to match instructional methods to selected learner characteristics. For instance, in this study computers are used in studying the same content by different learning strategies -- one with a variety of links; the other being unidirectional. In this manner, it may be possible to detect differences in individual capabilities with different approaches to the same learning goal.

It has been shown that the structure of a task interacts with a learner's ability, the studies show that mostly low structure benefits higher ability students and high structure is more beneficial for low ability learners (Cronbach & Snow, 1977; Snow & Lohman, 1984). This differential will be explored in the present study, which compare these learning strategies to determine attention, knowledge acquisition and retention of learners. However, the type and level of content as well as the level of cognitive ability is critical to

the outcome. A dissertation study by Thede (1995) compared constructivist and objectivist frameworks for computer aided instruction. The results showed that the objectivist group scored significantly higher on recall questions, although the difference between the groups were insignificant on the comprehension and application questions. Therefore, one type of instruction format may be better than another, depending on the type of knowledge acquisition and retrieval, which is expected following instruction. Since interactions with instruction, structure and ability occur, aptitude tests have been used an index of general ability (Koran, Koran, & Baker, 1980).

In summary, ATI research suggested that for a learning strategy task that involves attention, knowledge acquisition, and retention for strategies of constructivism, objectivism, and self-regulated learning in electronic/web-based media, aptitudes of general and verbal ability, learning strategy ability and attitudes were appropriate to test for aptitude-treatment interactions.

Summary

Electronic educational information via the World Wide Web may be the ultimate informal learning setting and as such could provide another powerful mechanism to supplement instruction. One of the many strengths of informal settings is the capability for it to occur anytime, anywhere and anyhow, which is capitalized with computers and the increasing availability and access of computers in society. Therefore, the results of this study has implications for how we may be better able to serve the general educational principles of knowledge acquisition while encouraging self-regulatory learning in the ultimate informal learning environment--Cyberspace.

Hypotheses

Based on the prior literature review, the following null hypothesis were formulated (all hypothesis were tested at an $\alpha = .05$):

1. There is no significant difference in post-assessment scores between the constructivist and the objectivist presentation formats on web-based learning.

2. There is no significant relationship between post-assessment scores and the student's gender, age or racial identity.

3. There is no relationship between the aptitudes of verbal comprehension and the post-assessment score.

4. There is no significant relationship between attitudes towards computers and post-assessment scores.

5. There is no significant relationship between self-regulation/self-efficacy and post-assessment scores.

CHAPTER 3
METHODOLOGY

An informal pilot study using ten participants was conducted during the fall of 1998 to assess and troubleshoot the WebPages used for the study. The directions and format of the pages were modified based on the outcomes from this pilot study.

Based on the aforementioned research, the hypotheses were formulated: (All hypotheses will be tested at $\alpha = .05$).

1. There is no significant difference in post-assessment scores between the constructivist and the objectivist presentation formats in an on-line learning environment.
2. There is no significant relationship between post-assessment scores and the participant's gender, age, or racial identity.
3. There is no relationship between the aptitudes of verbal comprehension and the post-assessment score.
4. There is no significant relationship between attitudes towards computers and post-assessment scores.
5. There is no significant relationship between self-regulated learners or self-efficacy and post-assessment scores.

Setting

This study was conducted using computers equipped with Internet access in various laboratories, homes and businesses on and around the University of Florida (UF) campus. To ensure equal access to all participants, the UF maintains several computer laboratories with adequate hardware configurations and software applications to support Internet connections to all UF students.

Participants

The participants for this study were one hundred and forty-five volunteer post-secondary students from the Engineering Research Center (ERC) and the College of Engineering at the University of Florida. They included 84 male and 61 female students of different ages with mixed cultural identity differences (see tables 3-1, 3-2 and 3-3).

Table 3 -1. Gender Distribution of Participants.

	Males	Females	Total Number
Constructivist Group	44	24	68
Objectivist Group	33	32	65
Control Group	7	5	12
Total Number	84	61	145

Table 3-2. Age Distribution of Participants.

Age (years)	Number of Participants
18-21	85
22-26	41
27-30	19

Table 3-3. Racial Identity Distribution of Participants.

Racial Identity	Total Number
White	111
African American	7
Native American	3
Hispanic	11
Asian Pacific	13

Data were collected during the final eight-week period in the fall semester, 1998. Upon logging on to the Internet, students were presented an information sheet describing the study, then asked to click on a submit button to acknowledge informed consent as per an Institution Review Board (IRB) requirement (Appendix A). Participants were randomly assigned to one of two treatment groups or a control (table 3-4). The design is a pre-assessment test/post-assessment test with a control group. The effect of the pre-assessment is not evaluated directly because this instrument influences all participants, but the data are used in the analysis of covariance to account for prior knowledge. The analyses are conducted on data collected from the 145 participants.

Table 3-4. Study Design.

Attitude, Verbal, and Self-Regulation/ Efficacy	Group Assignment	Pre-Assessment	Treatment #1 Constructivism	Treatment #2 Objectivism	Post-Assessment
O	R (n=68)	O	X1		O
O	R (n=65)	O		X2	O
O	R (n=12)	O			O

All information was numerically coded by the participant's last four digits of their social security number, and confidentiality was maintained to the extent stated and required.

Independent Variables

The following characteristics of the students were used as independent variables for the study: gender, age, racial identity, attitude toward computers, self-regulated learning/self-efficacy and aptitude. Gender, age, racial identity, attitudes and self-regulated/self-efficacy were obtained through pre-study questionnaires and surveys. Aptitude information was obtained with a verbal comprehension test.

Gender, Age and Racial Identity

Gender is a true dichotomous independent variable with the sample of 145 participant's distributed as shown in Table 3-1. Age was measured on a continuous scale. Since post-secondary students are the target population, ages varied between 18 and 30 years old. Although 289 participants logged onto the webpage and 182 completed the study, 145 science and engineering participants below the age of 30 were selected for the study based on the completion of all forms and their major area of study. The distribution is shown in Table 3-5. Racial identity was measured as a categorical variable. Post-secondary engineering and science students are not equally divided, racially. The distribution of the 145 participants is shown in Table 3-6.

Table 3-5. Participant Continuous Age Distribution.

Age	18	19	20	21	22	23	24	25	26	27	28	29	30
#	6	21	29	28	17	9	5	10	1	8	3	6	3

Table 3-6. Racial Identity vs. Gender Distribution.

Racial Identity	White	African American	Native American	Hispanic	Asian Pacific	Total
Male	59	6	2	7	10	84
Female	52	1	1	4	3	61
Total	111	7	3	11	13	145

Attitude Towards Computers

Attitude was measured on an ordinal scale as an independent variable with a twenty-four item, 5-point Likert scale on-line computer attitude survey (Appendix B). The survey was administered to each participant prior to the completion of the instructional module. Results were analyzed using central tendency, reliability and standard error of measures. A pilot study was performed on this survey instrument to determine test reliability indices (Appendix C). Survey results included central tendency, reliability, standard error and item response theory measurements. The instrument produced the following results: internally consistency ($\alpha = .86$), reliability (split-half = .83; w/Spearman correction = .90) and was determined to be predictive of some attitudinal domains toward electronic information.

Self-Regulated Learning/Self-Efficacy

Self-regulated learning and self-efficacy was measure on an ordinal scale as an independent variable with an eighty-one item, 5-point Likert scale questionnaire called the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich & Garcia, 1993). A sample that the participant would indicate whether it is true of them or not would be:

The most satisfying thing is to understand content thoroughly.

The MSLQ was administered prior to the completion of the instructional module. Previous results have shown that the MSLQ scale is to be a reliable and valid measure of self-regulated learning. The MSLQ is a self-report instrument designed to assess college student's motivational orientations and their use of different learning strategies and is based on a general cognitive view of motivation and learning strategies. There are 81 items, which takes approximately 20 minutes to complete.

Aptitude

A cognitive vocabulary test was used to determine verbal comprehensive scores. A sample of the verbal items provided for this study is:

Integrated

1 provender
2 connected
3 chorister
4 proscriptive
5 effulgence

Previous research has demonstrated that verbal comprehension is a good example of general aptitude. Scores ranged from 5-37 out of a 48 possible with a mean value of 21.

Pre-Assessment

In addition to a general chemistry section, all participants were provided a criterion referenced written pre-assessment (from the Engineering Research Center instructional manuals) (Appendix D). All questions were based on the concepts presented in the web-based instruction modules. Content validity was established by experienced judges in the area of science education, informal settings (museums and zoological parks), and an ERC education specialist. Split-half reliability was calculated using the Spearman-Brown formula. The pre- and post-assessments consist of two subsections. The initial subsection measures basic general chemistry knowledge and the second subsection focuses on the specific information which the module presents. There has been prior research in the area of constructivism versus objectivism which has used only forced choice assessments (Thede, 1995). This research has generally shown results of significantly higher total and recall scores for the more structured, objectivist instruction. Chang (1994) also reported that students in the constructivist approach did not perform significantly higher than students in the conventional treatment on multiple-choice scores. For this study, a combination of both forced and free choice items were used for the assessments.

Experimental Design

The design is a modified pre-assessment/post-assessment with control group design. Both treatment and control groups were randomly assigned, and all were provided with pre- and post-assessments to assure equivalent groups. The only difference between each of the three groups is that Treatment #1 received a contructivist instructional module

with multiple links; Treatment #2 received an objectivist module with a linear path and the control group did not receive an instruction module.

Instrumentation

The instruments used for this study include an on-line computer attitude survey, a Motivated Strategies for Learning Questionnaire (MSLQ); a verbal comprehension test; and pre- and post-assessments.

Instructional Materials

Contructivist Instruction Module

A complete copy of the contructivist instructional module is presented in Appendix E. A true constructivist environment in Cyberspace would allow the user to access all areas of the Internet. However, in this study, it is impractical. Therefore a constructivist environment has been operationally defined as one, which allows the participant to access several internal links to build their knowledge of the subject (see figure 3-1).

THE NATURE OF THE PARTICLE SURFACE

There are many physical and chemical measurements, which are descriptive of the nature of a particle system. The use of the term "particle system" implies the existence of a finely divided particle phase in a continuous phase. The particle phase is generally one of finely divided solids or liquids and the continuous phase is a liquid.
What might be an organic example of this liquid phase?
What physical measurements of particles could be useful?

Page 1 Answers	**Particle Systems**	**<- Back**	**Forward ->**

Figure 3-1. Constructivist Instructional Module Example WebPage Display.

Objectivist Instruction Module

A complete copy of the objectivist instructional module is presented in Appendix F. For this approach, material is presented in a prescribed linear order. The computer module allows the participant to examine the textual information for a duration of their choosing, however after the completion of a screen, they are presented with only one link which forwards to the subsequent page of text (see figure 3-2). The participant is allowed to move backward to a previous page to review previous topics.

THE NATURE OF THE PARTICLE SURFACE

There are many physical and chemical measurements, which are descriptive of the nature of a particle system. The use of the term "particle system" implies the existence of a finely divided particle phase in a continuous phase. The particle phase is generally one of finely divided solids or liquids and the continuous phase is a liquid such as water, an organic such as alcohol, or an oily liquid such as a hydrocarbon. Physical measurements of particles, e.g., density, porosity, linear size, shape, surface area, etc., are very useful. Such information can be used to understand and predict how to modify the particle system.

<-Back			**Forward ->**

Figure 3-2. Objectivist Instructional Module Example WebPage Display.

Post-Assessment

A criterion referenced written post-assessment was provided following the instructional modules (from ERC instructional manuals) (Appendix G). All questions were based on the concepts presented in the web-based instruction modules. The post-assessment provided the exact same items as the pre-assessment.

Procedures

The participants were undergraduate and graduate students recruited from the Engineering Research Center (ERC) and the College of Engineering at the University of Florida. Participants were asked to read and submit an electronic IRB approval consent form. Following consent, the participant completed the following forms: a computer attitude survey; a Motivated Strategies for Learning Questionnaire (MSLQ) which determined the participant's self-regulated/self-efficacy abilities; and a verbal comprehension test to determine general aptitude. These forms were followed by a pre-assessment, then the instructional module and subsequent post-assessment. Each participant was randomly assigned to one of the two treatments or the control by drawing a number out of a hat with a web address in class or by selecting “1”, “2” or “3” on the Internet instructions. The number correlates to one of three web addresses: the constructivist instructional module, the objectivist module, or the control site. If the participant accessed the web page directly, they randomly selected one of the three pathways. Once they identified which computer system they would be using and logged on to the Internet, they typed the randomly drawn web address. The address is entered at the top of their Internet Browser where a display of [http://www......... .com/] is found. After entering the address, they press the enter key to signal the browser to locate the web site. The address selected transfers the participant’s Internet signal to the ERC homepage. At the bottom of this homepage, there is a “Learning Study” link provided. Once the study link was initiated, complete detailed instructions were downloaded (Appendix A). They were instructed to complete the forms entirely and individually on-line. After completing each form, they were to continue to the subsequent form using the

"FORWARD" link. When they were complete with the final post-assessment, they were asked to submit their responses to complete the study.

Data Analysis

An analysis of covariance (ANCOVA) was used to determine the format/participant relationships among the dependent variable, the achievement on each of the formats and the independent variables, gender, racial identity, verbal aptitudes, attitudes, and self-regulated learning/self-efficacy. Scores on the post-assessment were not significantly different between each type of instructional format for web-based learning. Likewise, gender and age did not affect the post-assessment scores. It was not possible to determine differences in racial identity due to the low number of participants. However, it was observed that the older the participant, the better they performed after completing the objectivist instructional module. Attitudes toward the computer, verbal aptitudes and self-regulated/self-efficacy learning did not affect post-assessment scores significantly.

CHAPTER 4
RESULTS

Out of the 289 students that participated in the study, 145 science and engineering majors completed all of the required five forms after completing either a constructivist or objectivist instruction module or the absence of a module, which was used as a control. The five forms were analyzed and each of the null hypotheses was tested. The corresponding results are described below. These hypotheses were designed to measure the impact of an on-line instructional module on learning through the Internet. The five forms included:

1. An on-line computer attitude survey (with demographic questions)
2. A Motivated Strategies for Learning Questionnaire (which evaluates self-regulated learners and self-efficacy)
3. A verbal comprehension test (a general indicator of aptitude)
4. An instructional pre-assessment; and
5. An instructional post-assessment (exactly the same as the pre-assessment).

Descriptive Statistics

The criterion-referenced assessment(s) used in the study consisted of 20 questions each (Appendix D). Two subsections of 10 items each covered general chemistry and water chemistry knowledge, which contained material specific to the learning modules.

The second subsection of items were used for data analysis. An item difficulty analysis of the pre- and post-assessment, as measured by percent correct on each item, was conducted (Table 4 -1). Three items on the pre-assessment and all ten items on the post-assessment resulted in a percent correct rate of 0.50 or higher. In addition, reliability data is presented in table 4 -1.

Table 4 -1. Pre/Post-Assessment Item Difficulty and Reliability Data.

Item Difficulty	Pre	Post
0.91-1.0	0	0
0.81-0.90	0	0
0.71-0.80	1	2
0.61-0.70	2	2
0.51-0.60	0	6
0.41-0.50	2	0
0.31-0.40	2	0
0.21-0.30	2	0
0.11-0.20	1	0
0.00-0.10	0	0
Total Number of Items	10	10
Cronbach's Alpha	.8341	.8435
Split half reliability	.8615	.8408
Split half w/Spearman	.9256	.9135

The 145 data points were used in this study because they contain results for the pre- and the post-assessment, which is required to determine the score differential before and after the instructional module(s) were reviewed. Drop out rate should be considered whenever activities are performed remotely via electronic media, such as the Internet.

The number of forms completed by the participants varied from one page to the completion of all five forms. The following table 4 -2 details this data.

Table 4 -2. Participant Completion Form Distribution.

Age	Complete (a)	Complete except for Posttest (b)	Incomplete (c)	First Page Complete (d)	Total Number (e)	% Complete (f)
Total Number	185	37	33	34	289	64
Engineers and Scientists 18-30	145	0	0	0	145	100

(a) – Number of participants who completed all forms of the study.
(b) – Number of participants who completed all forms except the post-assessment.
(c) – Number of participants who completed some of the forms.
(d) – Number of the participants who only completed the first page of the forms.
(e) – Total number of participants who accessed the web page,
(f) – Percentage of participants who completed the study.

As one of the demographic items, the participant was asked to provide their major area of study in school. Although a test relating major to formats was not performed, this response enabled the separation from non-technical participants. Table 4 -3 presents the distribution of major areas of study categories of participants.

Table 4 -3. Distribution of Participant Major Study's.

Major	Males	Females	Total
Chemical Engineer	13	7	20
Civil Engineer	5	1	6
Computer Engineer	4	3	7
Electrical Engineer	2	3	5
Environmental Engineer	21	14	35
Mechanical Engineer	22	13	35
Other Engineer	7	10	17
Chemist	6	5	11
Other Sciences	4	5	9
Total Number of Participants	84	61	145

Hypothesis 1

Hypothesis one states that there is no significant difference in post-assessment scores between the constructivist and the objectivist presentation formats in an on-line learning environment. Out of the 289 participants to access the web page, 145 participants were selected for data analysis. The difference in these numbers are itemized in table 4 -3 and represent incomplete data and a narrowing of the study population to examine only engineers and scientists. Incomplete data could not be used because it did not contain the post-assessment scores, which indicate performance differential before and after completing the instructional module. Participants were to complete several forms, review an instructional module and then complete an on-line post-assessment. Statistics and results for each group for each assessment are presented in table 4-4.

Table 4 –4. Descriptive Statistics for Instructional Module Groups.

Group	Attitude (max=5)	Self-Reg (max=7)	Verbal (max=48)	Pre (max=10)	Post (max=10)	n
Constructivist Mean	3.37	4.66	23.1	3.1	5.9	68
SD	1.17	1.65	9.4	2.4	3.2	68
Variance	1.42	2.84	88.2	5.7	10.4	68
Objectivist Mean	3.43	4.79	23.2	3.8	7.0	65
SD	1.15	1.60	8.4	2.5	2.8	65
Variance	1.38	2.73	70.7	6.3	8.0	65
Control Mean	3.50	4.63	24.6	3.9	4.0	12
SD	1.18	1.81	5.1	3.0	3.0	12
Variance	1.48	3.31	26.3	9.0	8.7	12

To determine the significance of this hypothesis, a simple analysis of covariance (ANCOVA) with general linear model procedures was performed comparing the format with participant post-assessment scores. Table 4 -5 presents the results of the ANCOVA which indicate there was a significant difference at $\alpha = .05$ between groups on post-assessment scores. However, the major difference occurred between the groups with instruction and the control. A follow-up linear model procedure demonstrated that there was not a significant difference between the two instructional module groups on the post-assessment scores, thus hypothesis one is accepted.

Table 4 -5. ANCOVA Source Table for Post-Assessment vs. Group.

Dependent Variable: Post-Assessment

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Group	2	97.077220	48.538610	**8.57**	0.0003
Pre	1	511.365459	511.365459	90.33	0.0001

Parameter	Estimate	T for Ho: Parameter=0	Pr >/T/	Std Err of Estimate
Group 1	2.532893107	3.39	0.0009	0.74773423
Group 2	3.092253463	4.14	0.001	0.74762496
Group 3	0.000000000			
Pre-Assessment	0.758958244	9.50	0.0001	0.07985691

Hypothesis 2

Hypothesis two states that there is no significant difference in post-assessment scores due to the participant's gender, age or racial identity. The ANCOVA with general linear models includes internal regression equations and examines the relationships among the dependent variable, the post-assessments, and the independent variables, the participants age, gender and racial identity. It provides estimates of the magnitude and

statistical significance of the relationships among the variables and therefore can identify those independent variables that are best predictors for learning on-line. For age distribution descriptive statistics refer to table 4 -6; for gender distribution, refer to table 4 -8; and for the distribution of racial identities, who participated in the study, refer to table 4 -10.

Table 4 -6. Distribution of Participant Age and Descriptive Statistics.

Age	Attitude (max=5)	Self-Reg (max=7)	Verbal (max=48)	Pre (max=10)	Post (max=10)	n
18-21 - Mean	3.41	4.74	23.2	3.1	6.0	85
SD	0.39	0.52	8.0	2.1	2.9	85
Variance	0.16	0.27	63.8	4.3	8.5	85
22-26 - Mean	3.43	4.74	21.7	4.3	7.0	41
SD	0.45	0.67	8.8	3.0	3.1	41
Variance	0.20	0.45	77.5	9.1	9.8	41
27-30 - Mean	3.36	4.52	26.9	3.5	5.8	19
SD	0.32	0.68	10.3	2.9	4.0	19
Variance	0.10	0.47	106.7	8.4	15.7	19

Part 1 of Hypothesis 2: Age

The age of the participants was restricted between 18 and 30 years. Although table 4-6 presents statistical data for three groups of ages, age was considered a continuous variable. The data in table 4-6 was created to examine the potential differences between a younger age group (18-21 years) and an older age group (27-30 years). The descriptive statistics for all three age groups were similar.

The ANCOVA was used to determine whether there was a significant difference between age groups on post-assessment scores. Table 4 -7 presents the results of the ANCOVA, which indicate that there was not a significant main effect at $\alpha = .05$ with age.

However, there is a significant interaction between age and treatment leading to the rejection of this portion of hypothesis two.

Table 4 -7. ANCOVA Source Table for Post-Assessment vs. Age.

Dependent Variable: Post-Assessment

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Group	2	39.317585	19.658793	3.51	0.0330
Age	1	0.005898	0.005898	0.79	0.5337
Age*Group	2	48.613319	24.306659	4.33	0.0151
Pre	1	400.258428	400.258428	71.38	0.0001

Parameter	Estimate	T for Ho: Parameter=0	Pr >/T/	Std Err of Estimate
Intercept	0.735848889	0.13	0.8969	5.66475041
Group 1 – Constructivist	7.192546058	1.17	0.2435	6.13843249
Group 2 – Objectivist	0.401197909	0.06	0.9486	6.20726260
Group 3 – Control	0.000000000			
Age	**0.068092426**	0.30	0.7678	0.23007969
Age*Group 1	**-0.302231921**	-1.21	0.2281	0.24956700
Age*Group 2	**0.106736978**	0.43	0.6701	0.24998681
Age*Group 3	0.000000000	0	0	0

These values are at an age of zero.

Part 2 of Hypothesis 2: Gender

The ratio of males to females in this study is relatively equal as indicated in table 4-8. The percentage of participating males (58%) approximately equaled the participating females (42%). In addition, all other values in this table are very similar, providing an indication that there may not be significant differences between technically oriented males

and females with regards to learning science specific information on the Internet. This trend was confirmed with an ANCOVA.

Table 4 -8. Distribution of Participant Gender and Descriptive Statistics.

Gender	Attitude (max=5)	Self-Reg (max=7)	Verbal (max=48)	Pre (max=10)	Post (max=10)	n
Male - Mean	3.36	4.64	23.4	3.6	6.4	84
SD	0.41	0.60	8.9	2.5	3.0	84
Variance	0.17	0.36	79.4	6.5	9.0	84
Female - Mean	3.48	4.82	23.1	3.3	6.0	61
SD	0.37	0.57	8.3	2.5	3.3	61
Variance	0.14	0.32	69.2	6.1	11.1	61

Table 4 -9 presents the results of the ANCOVA which confirm the earlier indication from the descriptive statistics that there was not a significant difference at $\alpha = .05$ between gender groups on post-assessment scores, thus this portion 2 of hypothesis two would be accepted.

Table 4 -9. ANCOVA Source Table for Post-Assessment vs. Gender.

Dependent Variable: Post-Assessment

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Group	2	39.317585	19.658793	3.51	0.0330
Gender	1	1.084855	1.084855	0.19	0.6608
Gender*Group	2	11.470010	5.735005	1.02	0.3625
Pre-Assessment	1	400.258428	400.258428	71.38	0.0001

Parameter	Estimate	T for Ho: Parameter=0	Pr >/T/	Std Err of Estimate
Intercept	0.735848889	0.13	0.8969	5.66475041
Group 1	7.192546058	1.17	0.2435	6.13843249
Group 2	0.401197909	0.06	0.9486	6.20726260

Table 4-9 Continued

Parameter	Estimate	T for Ho: Parameter=0	Pr >/T/	Std Err of Estimate
Group 3 - Control	0.000000000			
Gender 1 – Male	0.381604386	0.27	0.7912	1.43806591
Gender 2 – Female	0.000000000			

Part 3 of Hypothesis 2: Racial Identity

As indicated in table 4-10, it is not possible to determine significance between racial identities due to the overwhelming numbers of white participants (77%), unless a weighting of the statistics were performed on the total number of minorities (23%). This was not performed because of the low number of minority participants. Therefore, when the ANCOVA was performed, it did not indicate a significant difference between post-assessment scores and racial identity and thus, this portion 3 of hypothesis 2 resulted in an inconclusive result for significance.

Table 4 -10. Distribution of Participant Racial Identity and Descriptive Statistics.

Racial Identity	Attitude (max=5)	Self-Reg (max=7)	Verbal (max=48)	Pre (max=10)	Post (max=10)	n
White - Mean	3.39	4.74	24.4	3.5	6.4	111
SD	0.39	0.48	8.3	2.6	3.1	111
Variance	0.15	0.23	68.1	6.8	9.5	111
African American	3.44	4.88	24.4	3.9	6.6	7
SD	0.40	0.73	7.8	1.8	2.8	7
Variance	0.16	0.53	61.6	3.1	7.6	7
Native American	3.64	4.78	15.3	3.0	4.7	3
SD	0.21	0.38	8.1	1.0	2.9	3
Variance	0.04	0.14	65.3	1.0	8.3	3
Hispanic - Mean	3.56	4.55	18.4	2.5	5.0	11
SD	0.53	1.06	8.2	1.4	3.4	11

Table 4-10 Continued

Racial Identity	Attitude (max=5)	Self-Reg (max=7)	Verbal (max=48)	Pre (max=10)	Post (max=10)	n
Variance	0.29	1.12	67.9	2.1	11.8	11
Asian Pacific	3.38	4.57	19.6	4.1	6.6	13
SD	0.39	0.86	10	2.9	3.6	13
Variance	0.15	0.74	100	8.6	13.0	13

Hypothesis 3

Hypothesis three states that there is no relationship between the aptitudes of verbal comprehension and the post-assessment score. An aptitude measure of verbal comprehension ability was administered which provides a good indicator of general aptitude. The descriptive statistics for verbal aptitude are presented in table 4-11 and reliability statistics for this measure are presented in table 4 -12.

Table 4 -11. Verbal Aptitude Descriptive Statistics.

	Number	Mean	SD	Variance	Range	Possible
Verbal	145	23.3	8.6	74.6	5-44	48
Post-scores	145	6.3	3.1	9.8	0-10	10

Table 4 -12. Verbal Aptitude Test Reliability Data.

Parameter	Result
Cronbachs Alpha	.9002
Split Half	.8710
Spit Half (w/Spearman)	.9311

A significant difference was not determined by a simple ANCOVA between the verbal and post-assessment scores in this study. Table 4 -13 presents the results of the

ANCOVA, which indicate that there was not a significant difference at $\alpha = .05$ between post-assessment scores and the verbal aptitude scores, thus hypothesis three would be accepted.

Table 4 -13. ANCOVA Source Table for Post-Assessment vs. Verbal Aptitude, Attitude and Self-Regulated Learners/Self-Efficacy.

Dependent Variable: Post-Assessment

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Pre	1	334.515023	334.515023	59.57	0.0001
Group	2	18.083963	9.041981	1.61	0.2038
Verbal	1	1.777648	1.777648	0.32	0.5746
Attitude	1	0.838987	0.838987	0.15	0.6997
Self-Regulated /Self-Efficacy	1	0.487494	0.487494	0.09	0.7687
Verbal*Group	2	3.847060	3.847060	0.34	0.7106
Attitude*Group	2	15.718519	7.859259	1.40	0.2504
Self-Regulated /Self-Efficacy *Group	2	1.207739	0.603870	0.11	0.8981

Parameter	Estimate	T for Ho: Parameter=0	Pr >/T/	Std Err of Estimate
Intercept	- 1.438535010	-0.16	0.8766	9.24716711
Pre-Assessment	0.687603518	7.72	0.0001	0.08909053

Hypothesis 4

Hypothesis four states that there is no significant difference between attitudes towards computers and post-assessment scores. Computer attitudes were measured through a survey questioning participants about on-line learning materials, usefulness, and methods. A high rating on the 1-5 Likert scale represented a positive (good) attitude

toward computers. This survey was developed in a survey design graduate course and was pilot tested in the same course. Descriptive statistics for the computer attitude survey are presented in table 4-14, reliability statistics are presented in table 4 -15 and refer to table 4-13 above for the computer attitude ANCOVA data.

Table 4 –14. Computer Attitude Descriptive Statistics.

	Number	Mean	SD	Variance	Range	Possible
Computer Attitudes	145	3.41	1.16	1.40	1-5	5
Post-scores	145	6.3	3.1	9.8	0-10	10

Table 4 -15. Computer Attitude Survey Test Reliability Data.

Parameter	Result
Cronbachs Alpha	.7295
Split Half	.7046
Spit Half (w/Spearman)	.8267

There was no significant difference between computer attitude and post-assessment scores in this study. The results of the ANCOVA (table 4-13) indicate that there was not a significant difference at $\alpha = .05$ between post-assessment scores and the computer attitude scores, thus hypothesis four would be accepted.

Hypothesis 5

Hypothesis five states that there is no significant relationship between self-regulated learners or self-efficacy and post-assessment scores. An 81 item Motivated Strategies for Learning Questionnaire (MSLQ) with a seven-point Likert scale, developed

by Pintrich (1995) was used to determine participant self-regulated learning potential and self-efficacy (belief in one's own capabilities). A one on the scale represented when the statement was not true at all of the participant and a seven would indicate when it was true of them. There are essentially two sections to the MSLQ, a motivated section and a learning section. The motivated section consists of 31 items that assess students' goals and value beliefs and their anxiety. The learning strategy section includes 31 items regarding students' use of different cognitive and metacognitive strategies. In addition, this section includes 19 items concerning the student's management of different resources. Descriptive statistics for the MSLQ are presented in table 4-16, reliability statistics are presented in table 4 -17 and refer to table 4-13 above for the ANCOVA data.

Table 4 -16. Motivated Strategies and Learning Questionnaire Descriptive Statistics.

	Number	Mean	SD	Variance	Range	Possible
Self-Regulated/ Self-Efficacy	145	4.71	1.64	2.83	1-7	7
Post-scores	145	6.3	3.1	9.8	0-10	10

Table 4 -17. Motivated Strategies and Learning Questionnaire Reliability Data.

Parameter	Result
Cronbachs Alpha	.9177
Split Half	.9410
Spit Half (w/Spearman)	.9696

There was no significant difference between MSLQ parameters and post-assessment scores in this study. The ANCOVA (table 4 –13) results indicate that there

was not a significant difference at $\alpha = .05$ between post-assessment scores and the self-regulated learning/self-efficacy scores, thus hypothesis five would be accepted.

Summary

The five forms completed by the participants were analyzed to test five null hypotheses. The following hypothesis were tested at the $\alpha = .05$ level using an analysis of covariance. None of the five hypotheses could be rejected.

Hypothesis 1: There is no significant difference in post-assessment scores between the constructivist and the objectivist presentation formats in an on-line learning environment. Based on the ANCOVA, this hypothesis is accepted. The mean pre- and post-assessment scores for the constructivist module were 3.1 and 5.9 compared to the mean scores of the objectivist module of 3.8 and 7.0 out of a total possible of 10.

Hypothesis 2: There is no significant difference in post-assessment scores due to the participants gender or age. Based on the ANCOVA, part one (gender) and part two (age) of this hypothesis is accepted. There was a 30% difference between the number of males and females participating in this study. Mean values of the post-assessment scores were similar at 6.4 for males and 6.0 for females, thus significant differences between genders were not found and it appears that gender does not play a role in learning science specific information through the Internet. There are insignificant differences between individuals in the restricted age grouping between 18 and 30 years.

The final aspect of this hypothesis, racial identity, could not be established due to the heavy bias of white participants and thus the results were inconclusive.

Hypothesis 3: There is no relationship between the aptitudes of verbal comprehension and the post-assessment score. Based on the ANCOVA, this hypothesis is accepted and non-significant results were obtained between post-assessment scores and verbal aptitude.

Hypothesis 4: There is no significant difference between attitudes towards computers and post-assessment scores. Based on the analysis, this hypothesis is accepted.

Hypothesis 5: There is no significant relationship between self-regulated learners, self-efficacy and post-assessment scores. Based on the analysis, this hypothesis is accepted.

CHAPTER 5
DISCUSSION AND CONCLUSIONS

Two instruction modules were developed and offered on-line through the Internet to post-secondary engineer and science students to determine how well they learn through the Internet. Why should educators, administrators, parents and other stakeholders support research in the use of the Internet in classrooms and schools? There are many reasons for using the Internet. Some of the reasons include a higher equity of access, an infinite resource, students as active participants, motivational influence of authentic learning activities, student inquiry and cooperative learning, and improved assessment of student progress. However, a major issue of concern to educators is how to effectively design and evaluate different learning formats on the Internet (Huang, 1997). The Internet has gained attention in education today because of its prevalence and ability to provide low cost education, in addition to making learning easier, more effective, and increasing enjoyment (Palmieri, 1997). The introduction of computers into the educational arena represents yet another facet of learning in an informal or free choice setting, such as museums and zoos. Koran, Longino, and Shafer (1983) have found that a considerable amount of sensory stimulation and learning appears to be influenced in these free-choice settings. In addition, Koran (1984) indicates that curiosity is a response to a novel stimulus, including manipulatable and diverse objects such as computers. Therefore, the

more curious, the stronger the attracting and holding power, and the higher the attention, thus the more Internet visitors will learn.

Innovative approaches plus access to appropriate technologies will hopefully lead to the creation of new learning environments that are flexible and provide a custom education for each student, regardless of class size, time and distance constraints, previous preparation, and personal factors. However, passively hoping that normal learners will be able to activate appropriate learning strategies in an informal learning environment, such as the Internet, without guidance is insufficient to ensure successful learning and development. Therefore, with research in the area of learning theories (constructivism and objectivism) and self-regulation/self-efficacy, teachers can capitalize on the potential power of using the Internet as an informal learning setting for instruction. Greeno and Hall (1998) suggests the approach of situation cognition or situative perspective in these types of informal learning settings. A situative perspective emphasizes those practices in which students participate as they learn within the context of that particular learning environment. The Internet can provide this mechanism for participation. For example, if students' learning activities include formulating questions and proposing and explaining alternative solutions while they are using a computer, they can learn how to participate in those activities of inquiry. However, if they learn to give only the answers and explanations that are specified by teachers and textbooks, they are likely to learn the practices of memorizing.

Five forms were developed to gather data on how participants incorporated information presented in the instruction modules and what individual characteristics, such as gender, age and racial identities, may have assisted in their success. The study was

designed to (a) identify optimal instructional formats for on-line learning; (b) identify differences in response to presentation formats with respect to gender, age or racial identity; (c) examine the effects of verbal aptitudes on learning in different formats; (d) identify relationships between computer attitudes and achievement; and (e) identify the potential power for self-regulated learning and self-efficacy on Internet WebPages. The findings for each null hypothesis tested in this study are discussed below.

Hypothesis 1: There is No Significant Difference between Constructivist and Objectivist Presentation Instructional Formats in an On-Line Learning Environment.

When science instruction is presented in linear and non-linear formats to science and engineering post-secondary students via the Internet, there are no significant differences in their post-assessment scores. The mean pre- and post-assessment scores for students who completed a constructivist format were 3.1 and 5.9 compared to the mean scores of 3.8 and 7.0 for the students who completed an objectivist format. A score of 10 was possible for these assessments. As a comparison, the mean pre-assessment score for the control group was 3.9 and the post-assessment score was 4.0. Using analysis of covariance (ANCOVA), it was determined that regardless of participant characteristics, post-secondary, technically oriented students were able to learn using two different instructional module formats. The students were able to increase their post-assessment scores significantly over their pre-assessment scores as well as the control groups scores. Therefore there was improvement after completing the on-line instructional module. Limited prior research (Oliver & Herington, 1995; Chen, 1996; Chau, 1997; Block, 1997;

Wilson, 1997) has been performed on the topic of how people learn on the Internet supporting these findings. One study has shown that when constructivist and objectivist frameworks were compared for computer aided instruction, the results showed that the objectivist group scored significantly higher on recall, forced-choice questions (Thede, 1995). Open-choice items were not included.

Pure constructivism is not a theory about teaching. It is a philosophy about knowledge and learning. Learning occurs daily and relentlessly inside and outside of classrooms (Brooks & Brooks, 1993). In addition, the constructivist view, the role of the instructor is not to dispense knowledge but to provide students with opportunities and incentives to build concepts with the information provided (von Glaserfeld, 1996). It appears that the Internet should promote this approach. Even more critical is the increase use of the Internet today in education. The 1990's have seen the Internet coming into its own as students began to use it as a learning tool instead of only as a research vehicle. The nonlinear organization of text and graphics on the World Wide Web (WWW) allows greater user control. A constructivist approach permits clear mental representation of concepts and the freedom for each learner to explore (O'Carroll, 1997). In this manner, the constructivist approach allowed the participant to wander through the instructional module accessing information in his or her own individual style. Whereas, the participant completing the objectivist module experienced a linear approach to instruction. Both the constructivist and the objectivist modules contained the exact same information.

The finding of increased post-assessment over pre-assessment scores provides support for on-line education via distance learning curriculum using electronic media resources such as the Internet. Jegede (1989) has found that the Internet provides

teachers the opportunity to use several teaching methods in and out of their classrooms. The important point is that science can effectively be taught using specifically designed instructional modules placed on the Internet. Since there was no difference in post-assessment scores between the instructional formats, the manner in which lessons are presented did not prevent students from learning. The specific format or style of instruction will depend on the prior experience and the characteristics of the learner and the objectives of the course. Research shows that educational on-line use can increase student performance (Follansbee, 1997). Students are expected to be fluent in information literacy skills and science education on-line enables them to explore a new set of experiences (Ebenezer, 1999). These new experiences capitalized to a limited extent on the strengths of an informal setting. In addition to learning, curiosity, psychomotor development, interest, appreciation, motivation, and generalization all could be considered among the desired outcomes of a visit to an informal setting (Koran & Koran, 1986). Learning in informal settings is an ideal environment where activities create opportunities for students to practice scientific inquiry, and to do so in a self-directed fashion where learners take responsibility of their own self-regulated learning (Gunstone, 1991). Falk and Dierking (1992) have found that informal settings are attractive to learners because they are influenced by the physical aspects of objects outside of their normal experience and they encounter an array of atypical experiences. All of the aspects mentioned by Falk and Dierking (1992) are present in the informal setting of Cyberspace. However, different types of informal settings, such as that found on the Internet may have different effects on characteristics, such as cognitive, affective and psychomotor. Greeno (1993) contends that the central claim of situative theory is that cognitive activities should be understood

primarily as interactions between physical settings and the learner. Therefore the opportunity for learners to be situated in a setting which is closely related to the subject being taught should promote more appropriate knowledge acquisition.

Hypothesis 2: There is No Significant Difference in Gender, Age or Racial Identity with Post-Assessment Scores After Completing Different On-Line Instructional Formats.

Three primary demographic variables, including gender, age and racial identity were investigated to determine if one or more of these variables resulted in a significant difference in post-assessment scores after completing either the constructivist or the objectionist instructional module. As described earlier, of the 145 participants between the ages of 18-30, 84 were male and 61 were female and the racial identity was heavily biased toward white participants. A simple analysis of covariance (ANCOVA) was the statistical procedure used to examine the research hypothesis. This procedure revealed that gender and age were not significantly different between post-assessment scores and the variable of racial identity provided inconclusive results. Although many studies indicate that learners display more heterogeneity with respect to gender, age, and prior experience (Falk, Koran & Dierking, 1986), this phenomenon did not occur for this study.

Age:

It was anticipated that older participants might not perform as well on an on-line study due to the lack of computer experience during their early learning years. Overall the novel setting and lack of experience with computers could increase their anxiety and thus

decrease performance. However, since the study population was narrowed to post-secondary engineers and scientist between 18-30 years of age, a range restriction may have minimized this effect of age on the results of the study.

As stated earlier in accepting the hypothesis, the ANCOVA did not detect a significant difference between the age of the participant and their respective post-assessment scores. The mean participant age was 22 and the corresponding post-assessment mean value for those completing the constructivist approach was 6.20, and for those using the objectivist module, it was 6.79. The ANCOVA uses the mean scores and did not show a significant difference between age and post-assessment scores.

Table 5 -1. Age ANCOVA Source Table.

Dependent Variable: Post-Assessment

Parameter	Estimate	T for Ho: Parameter=0	Pr >/T/	Std Err of Estimate
Age	**0.068092426**	0.30	0.7678	0.23007969
Age*Group 1	**-0.302231921**	-1.21	0.2281	0.24956700
Age*Group 2	**0.106736978**	0.43	0.6701	0.24998681
Age*Group 3	0.000000000	0	0	0

At age = 0

Table 5 -2. Age General Linear Models Procedure with Least Square Means.

Group	Post Least Square Mean (at mean age)	Std Err Least Square Mean	Pr >/T/ Ho:LSMean=0
1	**6.20355342**	0.28608885	0.7678
2	**6.79314980**	0.29219505	0.2281
3	**3.63363589**	0.67836080	0.6701

However, after examining the learning slope of this data, it was determined that the lack of difference only occurred at the mean age. The ANCOVA uses a general linear model procedure, which produce slope estimate data for each parameter. When reconstructing the linear models graphically, an age distinction was evident. At the mean age of 22, the least square means produced a post score of 6.2035 for group 1 (constructivist); a 6.7931 for group 2 (objectivist) and the control data was 3.6336. When these data are used to calculate linear prediction through years (table 5-3), it shows that higher post-assessment scores are produced as participant age increases after completing the objectivist instructional module (see figure 5-1). This supports an earlier statement made by Thede (1995) concerning objectivist formats in computer aided instruction, although both forced and open-choice items were included in this on-line study.

Table 5-3. Linear Calculation of Years vs. Format.

Age	Format	Equation	Product
18	1 - Constructivist	6.2035 - (-.23) * 4 =	7.1235
	2 – Objectivist	6.7931 - (.18) * 4 =	6.0731
	3 - Control	3.6336 - (.07) * 4 =	3.3536
22	1	6.2035 =	6.2035
	2	6.7931 =	6.7931
	3	3.6336 =	3.6336
26	1	6.2035 + (-.23) * 4 =	5.2835
	2	6.7931 + (.18) * 4 =	7.5131
	3	3.6336 + (.07) * 4 =	3.9136
30	1	6.2035 + (-.23) * 8 =	4.3635
	2	6.7931 + (.18) * 8 =	8.2331
	3	3.6336 + (.07) * 8 =	4.1936

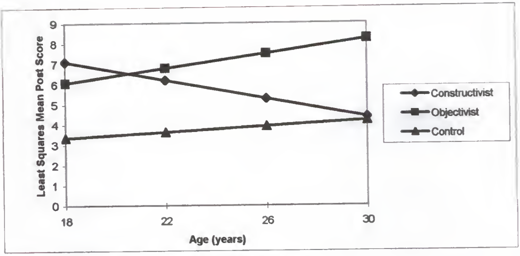


Figure 5-1. Linear Prediction of Format vs. Age

In this study, the restricted age range between 18-30 years produced a mean age of 22 and created a snapshot picture of data in time. When viewing the mean age of 22 on the graph (figure 5-1), it would initially appear that there is no significant difference between the two instructional modules as the ANCOVA indicates. However, examining the data in another manner indicates there could be a significant difference at $\alpha = .05$ between age groups on post-assessment scores, thus this portion of hypothesis two could be rejected when age is predicted beyond the means.

Although only a slight difference between post-assessment score exists for the two different instructional formats, this could be an indicator of a trend. If the study material was more general and younger students participated, the results may indicate that these younger learners may learn better through a constructivist approach. A conclusion that favors a constructivist instructional formats at lower ages would support Uddegrove's (1995) notion that teachers have recently shifted their educational approach from one of knowledge transfer (instructionalism or objectivisim) to one of knowledge building

(constructivism) which depends on inquiry, student collaboration and peer teaching. It appears that even in a study where age range was relatively restricted a trend in the way students learn may be apparent.

Also, the younger participants of this study may have had more experience with the new technology of the Internet and the constructivist approach that it may offer. In contrast, the older participants may have operated on historical learning schemas, which were predominantly objectivist in orientation. This conclusion could produce two differing opinions about the direction and development of instructional formats and the use of the Internet.

1. Is a constructivist instructional format best suited for younger learners only and post-secondary students perform better with objectivist approaches, such as lecture; or

2. Has there been a basic change in instructional philosophy, which coincides with the characteristics of the Internet's constructive environment that will benefit all learners.

Gender

The ANCOVA did not detect a significant difference between the gender of the participant and their respective post-assessment scores. Although various gender studies have resulted in males dominating the computer arena (Bernhard, 1992; Cassell, 1991; Collis & Williams, 1987; Comber, 1997; Wallace & Sinclair, 1995), this finding does not seem to be the case in this study where the science-related subject matter was restricted to participants with a highly technical background. There were 84 males and 61 females participating in the study which is a sufficient sampling that would allow a detection of significance if one were present. Many studies are not able to collect sufficient data points

from different gender groups and therefore cannot provide conclusive evidence to their effects. The mean pre- and post-assessment scores for male participants were 3.6 and 6.4 compared to female participant scores of 3.3 and 6.0. A score of 10 was possible. Other factors examined between male and female participants also produced similar mean scores.

1. Attitudes toward computers produced a male to female result of 3.36 to 3.48;
2. Self-regulated learning and self-efficacy self-evaluation resulted in values of 4.64 to 4.82; and
3. Verbal comprehension was 23.4 to 23.1.

One possibility for the non-significance could be attributed to the study's subject range restriction due to age, subject matter and ability. Technically oriented post-secondary students were solicited to participate in a science-based instructional module on the Internet. The participants represented only a fraction of the general population, specifically future scientists and engineers. Since the instructional module was science-based and the primary objectives of the study were aimed at determining how well technical people learn through the Internet, a wider range of participants were not included. However, if a more generalized instructional module was presented and other fields of study were included, results could be significantly different between males and females. Therefore it appears that the lack of difference between gender in this study could be that individuals with a technical aptitude learn the same regardless of gender. Additional research would be helpful in this area to determine when a less technical topic is used, if results would detect a significant difference between males and females learning through on-line resources.

Racial Identity

As mentioned in the previous section, insufficient data were collected for participants with different types of racial identity. Out of the 145 participants, 111 were White, seven African American, three Native American, eleven Hispanic, and three Asian/Pacific Islander. Therefore, this portion of the hypothesis has produced inconclusive results with respect to performance of racial identity's and their post-assessment scores for on-line instructional modules.

Hypothesis 3: There is No Significant Difference in Verbal Aptitudes with Post-Assessment Scores After Completing Different On-Line Instructional Formats.

The ANCOVA did not detect a significant difference between the verbal comprehension of the participant and their respective post-assessment scores after completing either a constructivist or an objectivist instructional module. Verbal comprehension is the ability to understand the English language. A verbal comprehension test was used to determine general aptitude scores. Test reliability data calculated for the verbal assessment resulted in a Cronbachs alpha of .9002, a split half reliability of .8710, and with a Spearman correction, the split half reliability is .9311. Verbal comprehension was used as an indicator of general participant aptitude. Since interactions with instruction, structure and ability occur, aptitude tests have been used an index of general ability (Koran, Koran, & Baker, 1980). Aptitude has been defined as any characteristic of the individual, which functions selectively with respect to learning; that is, which facilitates or interferes with learning from some designated instructional method (Cronbach & Snow,

1977). Aptitude-treatment interactions (ATI) reflect the notion of tailoring instruction to important student characteristics. They refer to differences in student outcomes as a function of the interaction of instructional conditions with student characteristics. Interest for science educators stem from the possibility that ATI may be used to adapt science instruction to fit different learners optimally (Koran & Koran, 1984). The verbal ability mean of 23.3 (SD 8.6) may be slightly elevated with reported values for post-secondary males and females. This is most likely due to the fact that the participants of this study were post-secondary individuals with advanced degrees and experience or that post-secondary students have been pre-selected on the basis of high ability, which in turn, restricted its range.

It appears that regardless of general aptitude, most post-secondary students can learn effectively through on-line resources. This aptitude indicator provides additional evidence that the usefulness of the Internet for educational purposes outside of the formalized classroom may be possible. Other aptitude indicators could be used and compared to the results of this study.

Hypothesis 4: There is No Significant Difference in Attitudes with Post-Assessment Scores After Completing Different On-Line Instructional Formats.

Statistical analysis did not detect a significant difference between the computer attitudes of the participant and their respective post-assessment scores after completing either a constructivist or an objectivist instructional module. There are many factors influencing Internet usage and some measure of participant's attitude or degree of

technophobia should be included. An on-line computer attitudes survey was developed and piloted during a Survey Design course, spring, 1998 (Appendix B & C). This pilot resulted in reliability data for Cronbachs alpha of .8548 and split-half with a Spearman correction of .9045. This survey was used to identify relative positive or negative attitudes of the participants towards computers. Test reliability data calculated for the attitude survey for this dissertation resulted in a Cronbachs alpha of .7295, a split half of .7046 and with a Spearman correction, the split half reliability is .8267. The initial idea for this hypothesis from prior research was that people with positive attitudes about computers would perform better when using them while learning (Caprio, 1994; Comber, 1997; Durndell, 1995; Maurer, 1994). Age and attitude were variables that might cause the learner to become anxious, thus decreasing motivation, concentration and subsequent performance for on-line tasks. However, anxiety did not appear to be an issue in this study. People's attitudes toward computers typically range from apprehensive to confident and the differences in the educational arena are no exception. Differences in these attitudes can create an awkward learning environment. The result of student/teacher differences in familiarity of the new technology is a learning environment that resembles an Escher drawing of characters inhabiting a common physical space but living on different planes of existence that never interact (Bossert, 1997). The real value of computers is in helping us understand the powerful ideas that force us to change our ways of thinking and the most powerful weapon we have for exploring this new future is the one between our ears (Kay, 1997). However, there is some merit to caution because it is a mistake to emphasize connecting schools to the Internet without considering the kinds of thinking processes' students need in order to learn from the information they access (Goodman,

1997). The best approach is to take into account the curriculum orientation of teachers to help them identify barriers to the use of technology (Carroll, 1997).

Overall, it appears that in this study, attitude was not as important a factor to successful on-line learning, although a positive attitude may produce a more pleasant environment which may increase holding power, attention and possibly elevate performance for tasks of longer duration than this study provided.

Hypothesis 5: There is No Significant Difference in Self-Regulated Learners and Self-Efficacy with Post-Assessment Scores After Completing Different On-Line Instructional Formats.

A Motivated Strategies and Learning Questionnaire (MSLQ) developed by Pintrich (1995) was designed to assess post-secondary student's motivational orientations and their use of different learning strategies. In essence, this instrument identifies those who are self-regulated learners (learners controlling their own behavior, (Bandura, 1977)) and what they believe of their own capabilities (self-efficacy). Self-regulated learners are students whose academic learning abilities and self-discipline makes learning easier so motivation is maintained. Self-regulated learners a) tend to learn better under learner control; b) are able to monitor, evaluate, or manage their learning effectively; c) reduce instructional time required to complete the lesson; and d) manage their learning and time efficiently (Yang, 1993). Self-regulated learning strategies are actions and processes directed at acquiring information or skill that involve agency, purpose, and instrumentality perceptions by learners (Zimmerman, 1989).

One of the important questions for students, faculty and administration in post-secondary institutions today in the wake of massive influx of new computerized technology is the concept of distance learning (Sherritt & Basom, 1997). Colleges and universities are currently developing and offering various technical and non-technical courses remotely with variable success. Ideally, these programs would allow non-traditional students to participate in post-secondary courses while working full time jobs, or if they are simply unable to travel to the institution for on-site learning. Technology adds the ability for students to choose how, when, and where they participate in the learning experience and to bring together a vast wealth of previously unavailable learning resources (Forman, 1987). Also, distance learning allows the institution to generate additional revenue through tuition fees while minimizing the cost for the construction of additional facilities to house the students. However, in this seemingly win-win situation, the potential losers are the students, who are incapable of that kind of self-regulation through distance education on the Internet. In order to increase the success rate of distance learners, the institution could require a pre-assessment, which would determine the student's self-regulation in contexts such as the Internet. If the student achieved an acceptable score, they would be allowed to enroll in distance learning courses. If they were not acceptable self-regulated learners, the student could attend the course on-site where additional instruction, scheduling and mentoring are available.

Whereas self-efficacy influences the effort put forth, the duration and determination when confronted with obstacles and individual feelings. Students with high self-efficacy, work harder, persist longer when difficulties are present and achieve at higher levels. Successes raise and failures lower self-efficacy. Although low self-efficacy

is detrimental, effective self-regulation does not require that it be exceptionally high (Zimmerman, 1991). A slightly lower sense of self-efficacy has been shown to lead to greater mental effort and better learning than does extreme confidence (Salomon, 1984). A more specific self-efficacy instrument for computer learning would be helpful to identify potential candidates for distance learning based on this parameter.

The MSLQ is based on a general cognitive view of motivation and learning strategies. Norms are not provided for this survey because student's responses should vary as a function of different topics addressed. In this case, the research topic is computers and the Internet. For this study, test reliability data calculated for the MSLQ resulted in a Cronbachs alpha of .9177, and a split half reliability of .9410 with a Spearman correction of .9696. Historical research (Chi et al., 1994; Chi & Bassok, 1989; Hagen & Weinstein, 1995; Pintrich & DeGroot, 1990; Schunk, 1988) demonstrates that if an individual is able to regulate their own learning and believes highly in their own capabilities, an elevated post-assessment score would be predicted for this study. However, the results do not indicate this to be true. There are a variety of reasons for this unanticipated outcome which include the following.

1. Typically, successful post-secondary students in technical fields are self-regulated learners with high self-efficacy. Since most of the participants have this characteristic, a difference in this parameter was not observed.

2. Post-secondary students in the field of science and engineering have adapted to become effective self-regulated learners with high self-efficacy due to the abundance of objectivist instruction.

3. The particular science related subject matter requires higher order skills, which correlate positively with self-regulated learning and self-efficacy, thus the subject matter creates a restriction, which could not detect a significant difference.

Summary

The information processing (IP) model of learning and memory (Figure 2-1, Atkinson & Shiffrin, 1968, 1971) provided the theoretical foundation for this study and a method to examine the input stimulus of an on-line web page. The IP model provides for subsequent attention and learning by processing information from short term, or working memory to long term memory for retention and future retrieval. This study used the IP model in the informal setting of Cyberspace and examined how the constructivist and objectivist instructional modules were affected by the characteristics of the participants, such as gender, age, racial identity, attitude, aptitude and self-regulation/self-efficacy. The various on-line forms provided information on how each participant viewed themselves and how they performed through on-line instruction by completing each module and then responding to the assessments.

Electronic instructional modules were developed and downloaded on-line (http://www.erc.ufl.edu/Study/Consent.html) to quantify how post-secondary, technically oriented participants learn science concepts through the Internet. Although a significant difference was detected between the instructional groups and the control and one part of the original five hypotheses, the outcome of non-significant results have important implications for learners. There are promising indicators that the World Wide Web is a

viable means to increase student access, enjoyment and performance for education. Evidence on how the Internet can promote learning is not as forthcoming (Owston, 1997). The fact that all participants significantly increased their post-assessment over their pre-assessment scores indicates that post-secondary students can learn technical concepts through the Internet. This result provides some of the evidence Owston referred to and supports Forman's (1987) statement that the Internet can be highly valuable as a resource tool for education. This finding is an important contribution in support of using the informal setting of Cyberspace as a supplement to formal education in the classroom.

The only significant difference detected in this study was when age was compared to post-assessment scores. For the range of ages of this study, at age 18, the participant viewing the constructivist instructional module would score 7.1 in a post-assessment, although if projected to the 30 years upper limit of the study's age range, a lower score of 3.9 would be expected out of a possible 10. Therefore, the importance of teaching a particular format on-line to various age groups should be examined prior to implementation of instruction through the Internet.

There was no significant difference between gender and post-assessment scores after completing either instructional format probably due to an overall range restriction of the study. Gender does not appear to be a performance factor for technically oriented participants learning science-based information on-line through the Internet. This finding is important because there has been previous research (Cassell, 1991; Collis & Williams, 1987) indicating that gender affects were similar to mathematics and science topics, whereas males when compared to females achieved higher success. It could be that using the Internet potentially "de-genders" certain concepts and aligns the playing field for all

learners. In this manner, traditional concepts, which were thought to have been affected by gender, may find that using the Internet could minimize these undesirable affects. In addition, teachers would not be able to differentiate between males and females when assessing student progress if codes are used instead of names when submitting assignments.

The significant difference between racial identity and post-assessment scores after viewing each instructional module could not be determined due to the lack of a racially diverse sampling group. Predominantly white post-secondary students volunteered as participants in this study. Additional research may be needed in this area, although it could be that this parameter may follow a similar pattern as gender and using the Internet could "de-racialize" learning certain concepts, thereby aligning the learning field. A similar coding as used with gender could be used by the instructor to eliminate unintentional bias when assessing the academic performance of minority students.

There was no significant difference in verbal comprehension, an indicator of general aptitude and post-assessment scores after completing each instructional module. The restricted range of subjects is a very plausible explanation for this parameter as well as others previously discussed. The participants represented a specialized group which possessed uncommon characteristics and therefore a significant difference was not observed for many of the results. Verbal comprehension scores were slightly elevated from high school norms, probably due to the restricted sampling of scientist and engineers which have higher intelligence and more extensive backgrounds. It appears that all levels of students with different aptitudes would be able to learn from instructional material through the Internet. This finding is an important outcome because it essentially indicates

that all students, regardless of general aptitude and verbal ability could become successful on-line learners. The insignificance of this parameter on the difference of post-assessment scores may suggest an Internet equalizing effect for learners. However, to make a more general statement, participants with a wider range of characteristics would be required. Individuals could approach the on-line lesson with a wide variety of backgrounds, skill-sets, interest, abilities and objectives. Individual differences could be accounted for and each learner increases their opportunity for success.

There was no significant difference in computer attitudes and post-assessment scores after completing each instructional module. Again, the restricted target sampling of science and engineering majors may have a more uniform acceptance of computers and electronic media, thus, the format of this study did not intimidate them. Attitudes may affect older or technophobic participants who have not used computers during their education. However, a positive attitude toward computers could be fostered when direct, functional applications are presented as examples to the learners. Many historical technophobes are now technophiles due to the way they have correlated the use of computers to their interest, both professional and personal. Computers are not a one size fits all, but they have an inherent flexibility that can be modified by each user to adapt to a wide variety of topics. It seems that the major attitude hurdle for the technophobe to overcome may not be one of technological derivatives, but one of change and newness.

There was no significant difference in self-regulated learners with high self-efficacy and post-assessment scores after completing each instructional module. It is believed that science and engineer majors may incorporate these techniques in their learning process for a variety of reasons. Many of the individuals in this study may be classified as technically

oriented learners. In as such, these learners are more analytical and logical in their thinking. Therefore, regardless of the topic, format, or objective, these students will tend to use self-regulating mechanisms to set goals, monitor, self-assess and modify their approach. Zimmerman (1989) describes these self-regulated learning strategies as actions and processes directed at acquiring information or skills that involve agency, purpose, and instrumentality perceptions by learners. This strategy seems to be a critical factor for students to become successful on-line learners.

Suggestions for Further Research

Ideas for further research would include:

1. In order to generalize to a larger population, future work would need to broaden the sampling group to include participants with backgrounds other than science and engineering. In addition, more general instructional module, such as math or a lower level science could allow a wider range of individuals to participate. Winne (1998) states the obvious about how little is known about instructional design issues that affect students' learning with technology. Almost all technological applications have been designed on the basis of theories developed for nontechnological settings. Keeping this in mind, broadening the type of participants and the design of the website may better enable a comparison between the results from this study and the potential to generalize to a wider audience of on-line learners. The power of this type of further research is the ability to make a global statement about the effectiveness of on-line learning. One of the 16 Characteristics of Schools and School Systems for the 21st Century (American Association

of School Administrators, 1999), is that students and schools are connected around-the-clock with each other and the world through information-rich, interactive technology. Teachers, parents, students and administrators from all areas would then be able to evaluate the feasibility of using electronic media, such as the Internet, inside and outside of their classroom.

2. Morris (1989) has found direct effects of age and education on computer attitudes. Results from a study by Polyakov and Korobeinikov (1996) imply that the ability to train and retrain participants on a 10 minute computerized test decreases with age. In addition, Westerman (1995) found that older participants perform more slowly at computerized information retrieval. Therefore, further research in the area of minimizing the age range restriction of this study would be worthwhile. By testing primary, secondary and older learners, it may be possible to detect actual differences in students for on-line learning activities. For instance, Chang (1994) found that junior high school chemistry students produced much higher explanation scores when presented instructional material in a contructivist approach. A similar on-line study using constructivist and objectivist approaches could be administered to these learners modifying the content for each age group.

3. Robinson (1998) concludes that in order to have access to information, individuals will need computer skills that are not only technical, but also social and cognitive. Schools have not provided equitable access for all students. Minorities and the poor still lag behind suburban schools. These conditions undermine learning the language of computing. Bhatti-Sinclair (1997) agrees and indicates that rather than acting as a liberating force, information technology can reinforce inequalities in society. There is

evidence that groups which are discriminated against in society in general are further disadvantaged. Finally, Sutton (1991) has concluded that the use of computers has maintained and exaggerated inequities, with poor and minority students having less access to computers at home as well as at school. As technology advances, the cost of computer systems will decrease which may make them more common and therefore minimize the effect of availability. Future research should take into account whether the participants have easy access to computers. In this study, there was guaranteed access through the University of Florida computer laboratory system.

4. With respect to participant attitudes towards computers, Levine (1998) has indicated that beliefs lead to attitudes, and that attitudes are an important precursor to behavior. He further suggests that computer use has a positive effect on perceived computer self-confidence, as well as on computer-related attitudes. The attitudes of students toward computers are significant determinants of behavior that may influence computer utilization. Al-Khaldi and Al-Jabri (1998) has found that overall attitude affects computer utilization. In addition to attitude, other variables appeared to have a strong influence on computer utilization, namely the degree of computer experience, the degree of access to computers, and the number of computer- related courses taken. Anderson (1997) also agreed that course participation and previous experiences involving computer activities led to more positive attitudes toward computers. Courses with higher levels of direct involvement with computer applications led to the most positive attitude changes. Results from a Rocheleau (1997) show that computer ownership and student gender were the most important variables influencing computer usage. Student perception of their parents desire to use computers was also important. Findings demonstrate the influence

parents can exert in increasing the probability that their children will be heavy computer users. Further research should take these factors into consideration prior to experimental design development and implementation.

5. The correlation between distance learning and a self-regulated learner has been mentioned earlier in this study. Further evaluation of this critical component in web-based environments would be beneficial. Relatively little is currently known about the acquisition of self-regulation and what can be done to facilitate its development. Winne and Stockley (1998) indicate that educational technologies help students develop knowledge, skills, motivation and academically effective forms of self-regulated learning. Furthermore, the power of a computer can work with a student providing continuous monitoring as has been suggested in a model for self-regulated learning (figure 2-2) (Zimmerman, Bonner & Kovach, 1996). A limiting factor to determining an individuals own self-regulated learning ability is the identification of an effective tool. Although Pintrich (1995) has provided the questionnaire used in this study, additional research in the area of a more objective self-regulated learning measurement mechanism would be beneficial.

APPENDIX A
INFORMED CONSENT FORM
AND
ON-LINE DIRECTIONS

Department of Instruction and Curriculum
College of Education
1400 Norman Hall
University of Florida
Gainesville, FL 32611

Dear Student:

I am a graduate student at the University of Florida As part of my dissertation, I am conducting a study, the purpose of which is to learn about on-line knowledge acquisition of post-secondary students. I am asking you to participate in this study because you are a representative of the post-secondary population. Completing the study will last about 90 minutes. There are several forms which will be administered after you have read, type your name and submit this letter. You will not have to answer any question you do not wish to answer. The study will be conducted entirely on-line. Your identity will be kept anonymous as the intent is to gather data about on-line learning for post-secondary students.

There are no anticipated risks, compensation or other direct benefits to you as a participant in this study. You are free to withdraw your consent to participate and may discontinue your participation in the study at any time without consequence.

If you have questions about this research project, please contact me at 335-5877 x303, or my supervisor, Dr. M.L. Koran at 392-0723 x225. Questions or concerns about research participants' rights may be directed to the UFIRB office, University of Florida, Box 112250, Gainesville, FL 32611; phone (352) 392-0433.

After reading the remainder of this letter, click on the "submit" button. This will forward the form to the principal investigator and will not be associated with the subsequent study forms to ensure anonymity. By clicking on the "submit" button, you are agreeing to this letter and by completing the study, you give me permission to report your responses anonymously in my final dissertation to be submitted to my committee as part of my doctoral program.

Jace Hargis 10/1/98

Principal Investigator (Jace Hargis) Date

I have read the procedure above for the on-line knowledge acquisition study. I voluntarily agree to participate in the study and I have read a copy of this description.

Submit

On-Line Directions

For this study, you will be asked to complete several forms, review a lesson and then complete a post assessment on-line through the internet. This process will be completed at a location designated by you, on your own time and at your own pace. The intention of the preliminary forms is to assess various baseline characteristics about what you know and how you learn. If at any point, you have trouble responding or have questions, please try the best that you can to complete the forms. There are four preliminary forms which include:

- an On-line survey
- a Motivated Strategies for Learning Questionnaire
- a Verbal Comprehension test; and
- an Instructional pre-assessment

These forms are followed by a lesson which you will review and then a post-assessment will be presented for you to complete.

Now that you have identified which computer system you will be using and have logged on to the internet, a series of web pages will be downloaded on your screen. Each screen will contain specific instructions for the completion of each form. Please read and complete each form and then continue using the "next" link at the bottome of each page. You must complete the forms entirely and individually on-line. If you do not complete the study in one sitting, you will have to start at the beginning at another time and complete an informed consent.

When you are complete with the final post-assessment, there will be a "Submit" button at the bottom. Please click on this and then you will be finished.

Thank you for your participation.

APPENDIX B

On-Line Computer Attitude Survey

The following questions are anonymous, optional and will not affect your status in this course. **You do not have to answer any question which you do not want to answer**. This form is confidential to the extent permitted by law and will not be distributed outside the University of Florida College of Education.

Date: [ ] 1999

Course Number: [ ]

Course Title: [ ]

Major: [ ]

Gender: ☐ Male ☐ Female

Age: [ ]

Racial Identity: ☐ African American/ Black ☐ American Indian/Native American ☐ Asian/ Pacific Islander ☐ Hispanic ☐ White ☐ Other

Years of College: ☐ 1-2 ☐ 3-4 ☐ 5-6 ☐ 7-8 ☐ >8

Do you like computers? ☐ Yes ☐ No

Do you have Internet Access? ☐ Yes ☐ No

Do you typically use? ☐ Win 3.1 ☐ Other(specify) ____________ ☐ MAC ☐ Windows 95 ☐ DOS

Please read each question stem and following items carefully. Each question requires you to select a response ranging from NEVER to ALWAYS. After reading each question, shade in the circle above the response that best fits your first thought.

SECTION I - Learning Conditions:

1. When possible, do you select your general required courses based on:

The **time** of day scheduled?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

The **day** of the week scheduled?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

The **location** where its scheduled on campus?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

The **professor** teaching the course?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Section II - Learning Materials:

2. If the course you were taking provided lecture material/notes and sample exams on-line:

Would you take time outside of class to find the web site?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

If you found the web site, would you bookmark the page?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

In addition to the required text reading, would you read the material on-line?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Instead of the required text reading, would you read the material on-line?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you download the material electronically for later use?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you print the material?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you review and highlight the hardcopy printout and make additional notes?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you bring the printed material to class and follow along with the professor?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you use the on-line material to study for an exam or quiz?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Section III - Learning "On-line" Usefulness:

3. If you did use the material in some format and determined that it was useful:

Would you tell other classmates how useful you found it to be?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you assist them at locating and downloading the material from the web site?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you tell other **non**classmates about the usefulness of the on-line material?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you encourage other professors to provide on-line material?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you register for a course which offered on-line material over one which did not?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you still attend the lecture class?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you pay an extra course-specific fee for on-line notes?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Section IV - Learning Methods:

4. If you could select the way in which you learn:

Would you prefer to hear the information in a lecture?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you prefer to see the written textual information?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you prefer a combination of written AND verbal information?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you prefer to learn physically by a "hands-on" participation with the information?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

Would you remember more of what you learned if it was supplemented with "on-line" material?

○ Never ○ Seldom ○ Sometimes ○ Usually ○ Always

APPENDIX C
Pilot Study
On-Line Computer Survey

EDF6938 Survey Research Methodology Project

Motivational Attitudes of Post-Secondary Learners Toward On-Line Course Material

Jace Hargis
Department of Instruction and Curriculum - University of Florida

Electronic information via computerization and the internet has become a popular, even mandatory, media used in academia. The incorporation of new techniques involving electronic resources, may require the users to embrace the technology with positive attitudes in order for it to realize success. Typical of most educational reforms, a variety of hurdles exist that may create bottlenecks in the implementation of a quality electronic process. This survey report describes the process of instrument creation, piloting, administration, sampling concerns, data collection processing, reliability, validity and a discussion of the results. The instrument construct measures learner attitudes toward on-line electronic information in the form of learning conditions, materials, usefulness and methods. Survey responses are presented in a Likert format and results are analyzed using central tendency, reliability, standard error and item response theory measurements. Questions of concern are addressed and significance between groups is determined through t-test calculations. The instrument was found to be internally consistent, reliable and predictive of some attitudinal domains toward electronic information.

Introduction

Project Purpose and Background

The purpose of this report is to document the development, piloting, analysis, and reporting of a survey instrument on the motivational attitudes of post-secondary learners toward on-line course material. The intention of this survey is to evaluate the attitudes of post-secondary individuals who will be using computers to complete or supplement their studies, prior to the integration of electronic learning tools into their schema. Basically, it is human nature to embrace ideas which we are intrinsically driven; and likewise to avoid the alternative. Therefore, step one is to survey attitudinal perspectives of the user prior to implementation to ensure a more successful event. "Too often, the computer is used in the schools, as it is used in other social establishments, as a quick technological fix. It is used to cover up problems to create the illusion that they are being attacked." (Weizenbaum, 1984)

Purpose of the Survey

The purpose of this survey is to identify the motivational attitudes of post-secondary learners towards on-line course material. The formal issue addressed by the survey is whether or not college students will embrace, accept or reject the higher level academic

push to include electronic information into their courses. In addition to academia, the political agenda has joined the encouragement to use electronic resources in the classroom as an integral part of learning. Many professors have currently ventured out into 'cyberspace', producing on-line course material such as lecture notes, sample exams, exercises, homework's, and even surveys. Although no one has evaluated how or if this media increases achievement or produces affective results which may instill intrinsic motivation from the learner.

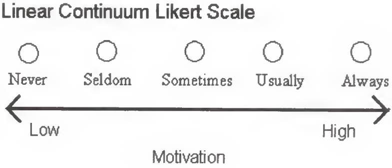
Survey Structure

The four-page survey is divided into two major parts and the latter divided into four sections. The first page includes background information such as date, course, major, gender, age, race, years of college, and computer items. This information can be potentially used to differentiate motivational attitudes between these categories and possibly identify reasons why some groups are more or less motivated towards computers. The second major part includes four sections with items relating to the section headings.

Section	Item Topic	Goal	Outcome
I. Learning Conditions	1. Time of Day 2. Day of Week 3. Class Location 4. Professor	Evaluate most productive environment	Realization of current scheduling choices
II. Learning Materials	5. Find the on-line site 6.Bookmark 7. In addition to text 8. Instead of the text 9. Download 10. Print 11. Review with notes 12. Bring to class 13. Use to study	Determine how participants would use the on-line information	Help the instructor create useful on-line information
III. Learning On-Line Usefulness	14. Tell classmates 15. Assist classmates 16. Tell non-classmates 17. Encourage others 18. Register for on-line 19. Attend class 20. Pay extra	To determine how important on information is to the learner	If shown useful, then increase material

Each section was designed to address a potential question or hypothesis. The intention of the first section is evaluate the preferred environment and conditions upon which the participant will be more productive. In the second section, the participant is directed that they are provided with on-line course material and the items inquire as to how they would deal with this added electronic information. This section enables the researcher to determine how the participants may use the information if/when it is available to them. The third section attempts to determine how important on-line material would be to the participant. If they are excited about downloading the material, assisting others, requesting that a professor present the information on-line or even pay extra for an on-line course, this would indicate an elevated sense of motivation on their part. The final section attempts to identify and integrate the participant's motivation toward multiple learning modes and their opinions of retention.

The actual survey items structured in a Likert format. The Likert scale contains five consistent selections ranging from Never, indicating low motivation, to Always for high motivation.



The items were formatted to produce responses, which would be complimentary to these standardized responses. A Likert format was selected for ease of administration, evaluation and interpretation. Also, this type of closed response spells out the response options, more specific and therefore able to communicate the same frame of reference to all respondents.

The Likert response structure and number of choices were determined to be acceptable identified by performing an item response theory (IRT) approach through a FACETS software program. Other data will be discussed in later reliability and validity sections, although one aspect of this program produces quantitative as well as qualitative visual evidence that a five point Likert scale was appropriate for this study.

The following probability curve graph represents the output of the program and given there were five responses provided, there should be five "humps" or nodes presented in the graph, one for each item. Therefore, the fit indices for the rating scale thresholds

support the five response selection and with respect to item fit and the rating scale structure works.

Probability Curves for Likert Scale Items:

```
   -3.0       -2.0       -1.0         0.0        1.0        2.0        3.0
    ++-----------+----------+----------+----------+----------+----------++
  1 |                                                                    |
    |                                                                    |
    |                                                                    |
    |111                                                                 |
    |   111                                                              |
  P |      11                                                         555|
  r |        11                                                    555   |
  o |          11                                                55      |
  b |            11                                            55        |
  a |              11                                        55          |
  b |                1                          44444444   55            |
  i |                 11                    4444        44*4             |
  l |                   1         3333333344            55  444          |
  i |                 222**22 333       44333         55       444       |
  t |            22222     *3*222     44     333    55            444    |
  y |         222        33 11    22*4          33*5                 444 |
    |     2222        333     11 44 22          55 33                   4|
    |22222          33        44*1    222    555     3333                |
    |           3333       444     111   5***2           3333            |
    |    3333333     444444        555***11   2222222        33333333    |
  0 |****************5555555555555         1111111111********************|
    ++-----------+----------+----------+----------+----------+----------++
   -3.0       -2.0       -1.0         0.0        1.0        2.0        3.0
```

The data coding methods for this survey included the following:

- Each survey item included Likert-type responses which ranged from "Never to Always". A response of "Never" received a value of "1", and a response of Always received a value of "5". The responses between were given values of "2, 3, and 4" accordingly.
- Each survey form was given an alphabetic identifier from A to BD.
- The numerical equivalent data was input into an Excel spreadsheet with respect to the identifier code or personal ID.
- Survey items were spelled out across the top of the spreadsheet differentiating the actual questions with a Q1-Q25 for ease of later calculations.
- Each course was individually entered on a separate tab of the same Excel worksheet to be able to later identify if one had weaker statistical inputs.
- A summation table was created which contained all 56 participant results.
- From this table, reliability measures such as central tendencies, variance, Cronbach's alpha, SEM, split-half and Spearman-Brown values were computed.

Reliability Analyses

- Reliability can be described as stability, consistency, or precision and may be demonstrated in different ways. In contrast to validity, which focuses on whether a

test yields scores from which valid inferences can be drawn, reliability merely reflects the consistency of the measuring device

Reliability Comparison Table

n	Cronbach's Alpha	Split-Half	Spearman Brown	IRT
20	.90	.89	.94	-
19	.81	.74	.85	-
17	.87	.73	.85	-
56 (total)	.85	.83	.90	.90

Validity Analyses

Validity is the ability of the scale to measure the concept of interest. Consequently, validity is the most important concept in assessing the efficacy of a measure. Validity can be thought of as a set of standards by which you judge things and are something to be argued, not proven. Reliability assessments are necessary, but they are not sufficient when examining the properties of a survey instrument. A test is valid to the extent that appropriate and useful inferences can be made from the test results. Testing a survey instrument for validity is more like hypothesis testing than like calculating correlations. It is much more difficult and time-consuming. For a scale to be valid, items for the scale must have come from the universe of all the items that could comprise the concept.

Hypothesis Item	t-test	p value	Sign/Non sign
1-2 vs. 3-4	3.46	.51	Significant
3-4 vs. >5	0.6	.82	Non significant
1-2 vs. >5	3.42	.96	Significant

- Do I have construct validity with respect to *age* differences?

Hypothesis Item	t-test	p value	Sign/Non sign
<21 vs. >21	0.04	.50	Non significant

- Does comfort with on-line material lead to lower class *attendance*?

Hypothesis Item	t-test	p value	Sign/Non sign
Comfort vs. Attendance	0.38	.64	Non significant

Discussion

The survey is intended to quantify attitudes for learning conditions, on-line learning material, awareness of learning styles, and hands-on informal settings as detailed during an oral presentation. The importance of determining motivational attitudes of selected post-secondary learners toward on-line course material can be seen in many current classrooms across the country. Many references have been cited with respect to using electronic information and many more will be forthcoming. Regardless of whether learners are technophobes or technophiles, all will encountered some level of computer interface in their schools, businesses and even their home. Therefore, the implications of this study are

potentially far-reaching. Many professionals of computer literacy have encouraged early learning in the electronic arena, beginning as early as possible. In this manner, children will develop with a feeling that computers are an integral part of their society and especially their natural learning environment. In this way, they hope to minimize the anxiety of novel learners. This approach validates this particular attitudinal study. In essence, the manner of incorporating computers as a natural part of what the learner is to expect from education is altering their predisposed fear of technology as a difficult, intangible part of their lives.

Primary Outcomes

The primary outcomes on motivational attitudes are data produced from the problems asked in the Introduction section of this report. One item that may be noteworthy to begin with is the similarities in results between the three distinctly different groups of participants. As far as the problems are concerned, the report has addressed them all, however, full support of original hypothesis has not been provided. In either case, even incorrect hypotheses tell us something. The first two problems of *are people being measured accurately* and *are the items working well*, were addressed in the reliability section. High, positive correlation coefficients were produced for Cronbach's alpha, split-half and Spearman-Brown values, therefore users should be confident that the reliability values for this instrument are high enough to permit use with confidence. The next three problems were addressed in the validity section; *is there a relationship between years of college and attitudes towards computers, do I have construct validity with respect to age differences*, and *does comfort with on-line materials lead to lower class attendance*. Overall, there appeared be significant difference between the extremes in years of college, however, the survey data did not indicate a significant difference between age and the attendance relationship. Details on why these occurred are presented in each section, but the major theme was that convenience sampling limited the sampling frame and therefore possibly biased the results. The final problem, *does the rating scale structure work*, is supported in the Structure section through results from the IRT program. The five-response selection was graphically demonstrated to produce five nodes and therefore it can be stated that the rating scale structure works.

Note: Items 11-20 are specific to the instructional module and therefore are used for data analysis.

APPENDIX D
Pre-ASSESSMENT
Engineering Research Center (ERC) Particle Science and Technology
A National Science Foundation Engineering Research Center

From Instructional Module Series: Raj Rajagopalan, Series Editor
Introduction to Chemicals Used in Particle Systems by Richard R. Klimpel, Ph.D.

Directions: Please respond to the following items. For the short response items, prepare a clear and concise response directly on this sheet. Please turn your completed assessment in to the investigator when you are finished. Thank you for your cooperation.

I. General Chemistry Knowledge

______1. How many electrons can there be in the 3d level?

a. 2 b. 4 c. 5 d. 10 e. 8

______2. Which element is a metal?

a. neon b. chlorine c. sodium d. argon e. sulfur

______3. How does the periodic table substantiate atomic theory?

a. Both are theoretical and cannot support each other.

b. Groups in the table have similar properties based on the same number of valence electrons.

c. All elements in a period of the periodic table have the same number of valence electrons.

d. Mendeleev declared consistency between the periodic table and atomic theory.

e There are eight elements in every row of the periodic table.

______4. A transition element in the periodic table is

a. sodium b. sulfur c. boron d. aluminum e. chromium

______5. A noble gas is

a. Al b. Ar c. Cl d. O e. C

______6. The number of protons in the nucleus of an atom is called the for the atom.

a. mass number b. family number c. electron number

d. atomic number e. group number

______7. Two atoms which have the same atomic number but different mass numbers:

a. sisters b. mothers c. daughters d. isomers e. isotopes

8. Briefly explain chemical bonding in terms of covalent and ionic bonds.

9. State Charles and Boyles law by definition or equation and provide an application.

10. Summarize the concept of titration using the terms neutralization, end-point, indicator, acid/base and pH appropriately.

II. Chemicals and Particle Systems

______11. Removing surface water from particles is

a. flocculation b. dewatering c. coagulation d. dispersion e. surfacting

______12. Promoting the incorporation of fine particles into a liquid continuous phase so that the resulting system consists of fine particles uniformly distributed throughout the phase is

a. flocculation b. dewatering c. coagulation d. dispersion e. surfacting

______13. A substance that preferentially adsorbs onto the interfaces between two different phases is a

a. flocculant b. dewaterant c. coagulant d. dispersant e. surfactant

______14. What is the opposite of coagulation and flocculation?

a. polymerizing b. dewatering c. settling d. dispersion e. surfacting

15. How do surfactants assist cleansing action?

16. What is the key implication of Stokes Law?

______17. To be considered colloidal, particles are typically less than 1
a. millimeter b. micromhos c. micron d. microgram e. meter

18. Differentiate between "philic" and "phobic" materials.

19. Name one common anionic surfactant.

20. Zwitterions are sometimes called
a. amphoteric b. polymeric c. salts d. acids e. nonionic

APPENDIX E

CONSTRUCTIVIST LEARNING MODULE

Introduction Web Page:

Engineering Research Center (ERC) Particle Science and Technology

A National Science Foundation Engineering Research Center

From Instructional Module Series
Raj Rajagopalan, Series Editor

Introduction to Chemicals Used in Particle Systems
Richard R. Klimpel, Ph.D.
May 1997

			Forward ->

Preface Web Page:

Preface

The purpose of this module is to introduce the use of chemicals in systems containing particles in a liquid continuous phase. The objective is to introduce the practical needs for several classes of chemicals coupled with how such chemicals work in particle systems from a fundamental viewpoint. Some of the more common chemical structures of individual members of each class will be presented. It is assumed that the reader has some knowledge of elementary concepts of inorganic and organic chemistry.

		<- Back	Forward ->

Web Page 1:

THE NATURE OF THE PARTICLE SURFACE

There are many physical and chemical measurements which are descriptive of the nature of a particle system. The use of the term "particle system" implies the existence of a finely divided particle phase in a continuous phase. The particle phase is generally one of finely divided solids or liquids and the continuous phase is a liquid.

What might be an organic example of this liquid phase?
What might be an oily liquid example?
What physical measurements of particles could be useful?
How are these properties useful?

Page 1 Answers	Other Particle Systems (page 3)	<- Back	Forward ->

Web Page 1 Answers:

Answers to Page 1:

Alcohol would be an example of an organic in this liquid phase.

Hydrocarbons would represent an oily liquid example.

Density, porosity, linear size, shape, and surface area are useful physical measurements of these particles.

Such information can be used to understand and predict how to modify the particle system in a desirable manner.

Consider this from your prior experience...
Can you think of other examples from a prior general chemistry course?

		<- Back	Forward ->

Web Page 2:

INTRODUCTION TO THE USE OF CHEMICALS IN PARTICLE SYSTEMS

Generally, the choice of the specific chemical is based on several factors including the end-use application and the required physical/chemical properties needed. In a sense, the chemical additives can be thought of as agents that deliberately promote a change or changes in the system. Often, the desired change is much faster or slower in the presence of chemicals than in their absence.

What kinds of specific changes can one expect from the use of chemicals?
If larger particles are produced, what advantages occur?
What are the major families of chemicals which assist in the creation of these larger particles?
A similar settling process is dewatering. What is dewatering?
Where is dewatering commonly performed everyday in every city?

Page 2 Answers	Other Particle Size Information *(page 4)*	<- Back	Forward ->

Web Page 2 Answers:

Answers to Page 2:

One commonly desired change is to promote particle coagulation or aggregation with other particles in a continuous liquid phase so as to make larger particles.

The larger particles settle faster in the liquid, thus producing a cleaner continuous phase devoid of particles.

The major families of chemicals which assist in the aggregate process are called **coagulants and flocculants.**

Dewatering is **the removing of surface water from particles, and filtration, which is the separation of solids from the liquid phase using some type of porous barrier through which the dispersion is passed.**

Dewatering occurs in **municipal water treatment plants which remove finely divided solids from large amounts of waste water.**

Consider this from your prior experience...
Are there other advantages or disadvantages that you are able to construct from this information?

		<- Back	Forward ->

Web Page 3:

A second common use of chemicals in particle systems is to promote the incorporation of fine particles into a liquid continuous phase so that the resulting system consists of fine particles uniformly distributed throughout the continuous phase.

What is this process called and hence the chemicals used to promote this are likewise called what?

What are some common examples of systems using dispersants?

Page 3 Answers	The Need for Dispersion (page 7)	Types of Dispersants (page 8)	Forward ->

Web Page 3 Answers:

Answers to Page 3:

The process is denoted as creating a *dispersion* and the chemicals used to promote and maintain the dispersion are called *dispersants*.

Paints and other types of coatings for use in homes, cars, etc. are common examples of dispersants. Almost any consumer product that is in a slurry form when used will also contain dispersants.

Consider this from your prior experience...
Have you used dispersants in a chemistry laboratory?

		<- Back	Forward ->

Web Page 4:

A third use chemicals is the addition of what are known as *surfactants* or *surface active agents*. A surfactant is a substance that preferentially adsorbs onto the interfaces between two different phases.

What are some examples of these different phases?

In most cases this adsorption promotes the expansion of the total area of the interface existing between the phases in the particle system. This is done with much less energy input than would be required without chemicals.

What is a very common household example of a surfactant?

What are other terms used to describe surfactant behavior?

Page 4 Answers	Definition of a Surfactant (page 9)	Surfactant Classes (page 10)	Forward ->

Web Page 4 Answers:

Answers to Page 4:

Examples of these different phases are **water, gas, oil, and solids**.

A very common household example of a surfactant is **ordinary soap**, which promotes the generation of small bubbles. These bubbles, in turn, assist the cleansing action.

Other terms used to describe surfactant behavior are **wetting agent and emulsifying agent**.

Consider this from your prior experience...
Have you used other surfactants before at home or in the laboratory?

		<- Back	Forward ->

Web Page 5:

THE NEED FOR COAGULATION AND FLOCCULATION

Coagulants and flocculants are generally used to promote the separation of particles from the liquid continuous phase, an engineering process which falls in the category of solid/liquid separation.

Why are chemicals necessary to separate particles, which are usually fine solids, from liquids, which are usually aqueous?

What factors are needed when using Stokes law?

What is one of the key implications of Stokes law?

Page 5 Answers	The Opposite of Coagulation(p. 7A)	<- Back	Forward ->

Web Page 5 Answers:

Answers to Page 5:

This need is demonstrated by the well-known Stokes law for describing the settling velocity of spherical particles in a fluid.

Stokes law involves the **velocity of the sphere; the radius; a gravitational constant; the specific gravity of the sphere and the liquid; and the viscosity of the fluid.**

One of the key implications of Stokes law is that **the larger the particle size, the faster the settling velocity.**

Consider this from your prior experience...
Can you think of practical example of Stokes law?

		<- Back	Forward ->

Web Page 6:

TYPES OF POLYMERS

While there are thousands of different commercially available flocculants and coagulants used industrially, the actual number of underlying polymer monomers involved is relatively small. Usually, lower molecular weight polymers act more as coagulators and higher molecular weight polymers act as flocculants.

What are the naturally occurring polymers?

How is starch and guar prepared and relatively speaking, how large of a molecule are they?

What type of polymer is mostly used today?

Why?

What are the primary categories of synthetic polymers and how are they distinguished?

Page 6 Answers	Other Charge Types (page 10)	Flocculants and Coagulants (page 5)	Forward ->

Web Page 6 Answers:

Answers to Page 6:

The naturally occurring polymers **such as starch and guar are nothing more than high molecular weight polymers of relatively simple sugars (polysaccharides).**

Starch can be prepared from many sources, **including corn and wheat, and it can have molecular weights ranging from a few thousand to six million. Guar is also derived from natural sources. Typical molecular weights of various guars range from 200,000 to 500,000.**

Synthetic polymers, which started to come into use in the 1960's, are commonly used today and have a number of advantages, most of which are related to the fact that **they can be carefully tailored to specific application.**

The primary categories of synthetic polymers are distinguished by their **charge type: nonionic (no charge), anionic (negative charge), and cationic (positive charge).**

Consider this from your prior experience...
Have you noticed some of the starch properties before (i.e. pasta)?

		<- Back	Forward ->

Web Page 7:

THE NEED FOR DISPERSION

There are many particle systems where fine particles need to be distributed throughout the continuous phase. The ease with which particles are distributed in the continuous phase so that each particle is completely surrounded by the liquid phase and no longer makes a permanent contact with any other particles is critical.

What is this process called?

Once a dispersion is created, the problem then becomes one of maintaining it, since particle systems have a natural tendency, starting with van der Waals forces, to coagulate and flocculate. Thus, dispersion is essentially the opposite of what two properties previously discussed?

The particle size plays a key role in the degree of dispersion possible in any given particle system. How does this relate to Stokes law previously presented?

If the particles are small enough, i.e., colloidal in nature, they are kept in suspension by simple Brownian movement. To be considered colloidal, particles are typically less than how many microns.

However, in systems containing coarser particles (greater than 1 micron), special attention is required to keep the system in a highly disperse state.

Generally the most practical way of maintaining dispersions is through the use of chemical stabilizers called dispersants.

What term is used when the particle size is relatively narrow?
What term is used when the size distribution is broader in the particle size it contains?

Page 7 Answers	Dispersants (page 3A)	Stokes Law (page 5A)	Forward -->

Web Page 7 Answers:

Answers to Page 7:

Dispersability is the ease with which particles are distributed in the continuous phase.

Coagulation and flocculation is essentially the opposite side of dispersion.

We are now using Stokes law in the **opposite way** than previously noted in this module.

To be considered colloidal, particles are typically less than **1** micron.

The system is said to be **monodisperse**.

The system is called **polydisperse**.

Consider this from your prior experience...

Have you experienced times during previous laboratory exercises that you were unable to disperse your solutions?

		<- Back	Forward ->

Web Page 8:

TYPES OF DISPERSANTS

The primary property of dispersants is their ability to disperse fine particles and to stabilize the dispersion. As the particles are dispersed within a continuous liquid phase, does the interfacial area between the particle and the liquid phase increase or decrease?

The action of the dispersant at this interface determines the behavior of the particle phase. In aqueous particle systems, dispersants generally have several hydrophilic groups along their chain and a hydrophobic backbone that is hydrocarbon in nature. What is the difference between hydrophilic and hydrophobic?

The adsorbed dispersant molecules have a tendency to look like common hair combs and to lie more or less parallel to the particle surface. In this form, the polar groups are directed outward into the liquid medium. What does "polar" mean in this context?

There are a number of common classifications of dispersants, including lignin sulfonic acids, formaldehyde condensation products, polyphosphates, and water soluble low molecular weight polymers.

The lignin derivative is a naturally occurring polymer produced by the paper making process. What advantages would you expect from this type of polymer? What disadvantages?

The second commonly used class of dispersants is formaldehyde condensation products, created by the condensation reaction of aromatic compounds with formaldehyde. How would these products be used industrially?

Polyphosphates have long been used in cleaning detergents, coupled with low water-soluble calcium and magnesium soaps, for dispersing dirt detached from the fibers in clothes. What household process has been improved by the use of these dispersants?

Page 8 Answers	Dispersants (page 3A)	Types of Polymers (page 6)	Forward ->

Web Page 8 Answers:

Answers to Page 8:

The interfacial area between the particle and the liquid phase **increases.**

Hydrophilic is attracted to water, whereas hydrophobic is repelled by water.

In this context, "polar" means **the items are charged.**

The advantages of lignin sulfonic acid is the tend to **adhere more strongly to hydrophobic particles and they are more stable relative to temperature increases**. However, the major disadvantage is their tendency to **foam and to discolor in the presence of light.**

These types of dispersants are widely used in **pigment systems, abrasives, glues, rubber, and cleaning soaps.**

The use of polyphosphate **dispersants improves with the degree of whiteness in the washed laundry**. However, because of environmental problems related to algae growth when waters containing phosphates are exposed to natural water systems and water treatment plants, their use is decreasing rapidly in most areas of the world.

Consider this from your prior experience...
Are there any other environmental issues which may be the cause of these dispersants?

Back Forward

Web Page 9:

DEFINITION OF A SURFACTANT

Surfactants, or surface active agents, have an amphipathic structure. What does that mean?

The first group of a surfactant is a *lyophobic* group that has very little attraction for the continuous liquid phase or solvent phase. In aqueous systems this is the hydrocarbon portion, called the *hydrophobic tail* or simply *tail*, of the surfactant. The second major grouping is a lyophilic group which has a strong attraction for the liquid phase or solvent. In aqueous systems this is often an ionic portion or a nonionic portion containing oxygen; it is called the *hydrophilic head*, or simply *head*. What are the tail and head's relative affinity for water?

Surfactants are chemicals that preferentially adsorb onto the interfaces of the different phases present in a particle system. Can you predict some typical particle systems in which surfactants are used?

Surfactants significantly reduce the surface tension or interfacial free energy between phases. It is important to point out, however, that surfactants are not the only surface tension reducing chemicals. There are surface tension reducing chemicals that are not surfactants. In many applications, surfactants can be thought of as a chemical substitute for what?

Page 9 Answers	Surfactants (page 4)	Phobic and Philic (page 8A)	Forward ->

Web Page 9 Answers:

Answers to Page 9:

Amphipathic means they **contain two major structural groupings**.

The hydrophobic hydrocarbon **tail has a weak affinity** for water in an aqueous environment while the hydrophilic **head has a strong affinity** for water.

Typical particle systems in which surfactants are used include **solid particles in a continuous aqueous phase, solid particles in a continuous hydrocarbon phase, air bubbles in aqueous fluids, organic or hydrocarbon droplets in aqueous fluids, and aqueous droplets in hydrocarbon fluids**.

Surfactants can be thought of as a chemical substitute for **high levels of mixing and agitation which would be required to maintain a high interface area in the system.**

Consider this from your prior experience...
Can you recall other compounds analogous to surfactants?

		<- Back	Forward ->

Web Page 10:

MAJOR CLASSES OF SURFACTANTS

There are four major groupings of industrially used surfactants. The first is the *anionic* surfactants, which, as a group, represents about 60% of the volume of all surfactants used industrially. What are three typical anionic surfactants?
Within this group, the most common chemicals used are sodium oleate; sodium lauryl sulfate; and dodecylbenzene sulfonic acid. The last two are the basic surfactants used in soap and cleanser products.

The second group is the *cationic* surfactants which as a group represent about 10% of the total volume of surfactants used. What are three typical cationic surfactants?

The third group is *nonionic* surfactants, which represent about 25% of the total surfactant volume used in industry. What are three typical nonionic surfactants?
The most common chemicals in this group used historically have been the polyoxyethylenated glycols; however due to stricter human health concerns involving surfactants, there has been a gradual shift to the use of other glycols which are safer. Can you predict what these type of surfactants are commonly used for?

The final group of surfactants is the *zwitterionic* surfactants, which are about 5% of the volume of surfactant usage. What are these surfactants sometimes called?
What are three typical zwitterionic surfactants? These chemicals, considered to be "specialty" surfactants, are more expensive than most of the other surfactants mentioned. Why are these surfactants called zwitterionic?
What type of reactions would zwitterionic surfactants become particularly useful in?
What are some household examples of these surfactants?

Page 10 Answers	Surfactants (page 4)	Definition of a Surfactant (page 9)	Forward ->

Web Page 10 Answers:

Answers to Page 10:

Typical anionic surfactants include **carboxylic acids, sulfonic acids, sulfuric acid, alkyl xanthic acids, and polymeric anionics.**

Typical cationic surfactants include **long chain amines; diamines and polyamines; and ammonium salts.**

Typical nonionic surfactants include **polyoxyalkylenated alcohol's; polyoxyethylenated glycols; and esters of carboxylic acids.** These type of surfactants are commonly used **to control and maintain the size of air bubbles in aqueous systems.**

The zwitterionic surfactants are sometimes called **amphoteric**.

Typical zwitterionic surfactants include **acrylic acid derivatives; substituted alkylamides; and n-alkyl betaines.**

Zwitterionic materials **have two different polar water associating groups within the same molecule.**

Zwitterionic surfactants become particularly useful in **applications that require much different responses as a function of changing pH.**

Many **skin and hair products** use zwitterionic surfactants.

Consider this from your prior experience...
Why would polarities play a part in the categorization of surfactants?

		<- Back	Forward ->

Web Page 11:

APPLICATIONS OF SURFACTANTS

The industrial and consumer oriented uses of surfactants are numerous. What are some common products and processes?

In particular, the use of surfactants in suspensions, emulsions, foams, aerosols, and for controlling wettability of materials is common industry. It should be apparent that there is not a single day in our lives that passes without our coming into contact with a surfactant used in a particle system.

Page 11 Answers	Surfactants (page 4)	Surfactant Classes (page 10)	Forward ->

Web Page 11 Answers:

Answers to Page 11:

Some common surfactant products and processes include **paints, soaps, shampoos, cosmetics, pesticide application, fuel additives, food product preparation, fabric softeners, detergents, dry cleaning, and wood preservatives.**

Consider this from your prior experience...
What indications of the uses of surfactants and other chemicals have you been exposed to before?

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APPENDIX F

OJECTIVIST LEARNING MODULE

Introduction Web Page:

Engineering Research Center (ERC) Particle Science and Technology

A National Science Foundation Engineering Research Center

From Instructional Module Series
Raj Rajagopalan, Series Editor

Introduction to Chemicals Used in Particle Systems
Richard R. Klimpel, Ph.D.
May 1997

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Preface Web Page:

Preface

The purpose of this module is to introduce the use of chemicals in systems containing particles in a liquid continuous phase. The objective is to introduce the practical needs for several classes of chemicals coupled with how such chemicals work in particle systems from a fundamental viewpoint. Some of the more common chemical structures of individual members of each class will be presented. It is assumed that the reader has some knowledge of elementary concepts of inorganic and organic chemistry.

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Web Page 1:

THE NATURE OF THE PARTICLE SURFACE

There are many physical and chemical measurements which are descriptive of the nature of a particle system. The use of the term "particle system" implies the existence of a finely divided particle phase in a continuous phase. The particle phase is generally one of finely divided solids or liquids and the continuous phase is a liquid such as water, an organic such as alcohol, or an oily liquid such as a hydrocarbon. Physical measurements of particles, e.g. density, porosity, linear size, shape, surface area, etc., are very useful. Such information can be used to understand and predict how to modify the particle system in a desirable manner.

Forward ->

Web Page 2:

INTRODUCTION TO THE USE OF
CHEMICALS IN PARTICLE SYSTEMS

Generally, the choice of the specific chemical is based on several factors including the end-use application and the required physical/chemical properties needed. In a sense, the chemical additives can be thought of as agents that deliberately promote a change or changes in the system. Often, the desired change is much faster or slower in the presence of chemicals than in their absence.

What kinds of specific changes can one expect from the use of chemicals? One commonly desired change is to promote particle coagulation or aggregation with other particles in a continuous liquid phase so as to make larger particles. These larger particles settle faster in the liquid, thus giving a cleaner continuous phase devoid of particles. The major families of chemicals which assist in the above process are called *coagulants* and *flocculants*.

Closely related to the above settling process are the processes of dewatering, which is the removing of surface water particles, and filtration, which is the separation of solids from the liquid phase using some type of porous barrier through which the dispersion is passed. Municipal water treatment plants which remove finely divided solids from large amounts of waste water are a common example of this type of chemical usage.

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Web Page 3:

A second common use of chemicals in particle systems is to promote the incorporation of fine particles into a liquid continuous phase so that the resulting system consists of fine particles uniformly distributed throughout the continuous phase. This process is denoted as creating a *dispersion* and the chemicals used to promote and maintain the dispersion are called *dispersants*. Common examples of systems using dispersants are paints and other types of coatings for use in homes, cars, etc. Almost any consumer product that is in a slurry form when used will also contain dispersants.

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Web Page 4:

A third use chemicals is the addition of what are known as *surfactants* or *surface active agents*. A surfactant is a substance that preferentially adsorbs onto the interfaces between two different phases (for example, water, gas, oil, and solids). In most cases this adsorption promotes the expansion of the total area of the interface existing between the phases in the particle system.

This is done with much less energy input than would be required without chemicals. A common example of a surfactant is ordinary soap, which promotes the generation of small bubbles. These bubbles, in turn, assist the cleansing action.

Other terms frequently used to describe surfactant behavior are *wetting agent* and *emulsifying agent*.

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Web Page 5:

THE NEED FOR COAGULATION AND FLOCCULATION

Coagulants and flocculants are generally used to promote the separation of particles from the liquid continuous phase, an engineering process which falls in the category of solid/liquid separation. Why are chemicals necessary to separate particles, which are usually fine solids, from liquids, which are usually aqueous? This need is demonstrated by the well-known Stokes law for describing the settling velocity of spherical particles in a fluid. Stokes law involves the velocity of the sphere; the radius; a gravitational constant; the specific gravity of the sphere and the liquid; and the viscosity of the fluid. One of the key implications of the Stokes law is that the larger the particle size, the faster the settling velocity.

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Web Page 6:

TYPES OF POLYMERS

While there are thousands of different commercially available flocculants and coagulants used industrially, the actual number of underlying polymer monomers involved is relatively small. Usually, lower molecular weight polymers act more as coagulators and higher molecular weight polymers act as flocculants.

The naturally occurring polymers such as starch and guar are nothing more than high molecular weight polymers of relatively simple sugars (polysaccharides). Starch can be prepared from many sources, including corn and wheat, and it can have molecular weights ranging from a few thousand to six million. Guar is also derived from natural sources. Typical molecular weights of various guars range from 200,000 to 500,000.

Synthetic polymers, which started to come into use in the 1960's, have a number of advantages, most of which are related to the fact that they can be carefully tailored to specific application. The primary categories of synthetic polymers are distinguished by their charge type: nonionic (no charge), anionic (negative charge), and cationic (positive charge).

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Web Page 7:

THE NEED FOR DISPERSION

There are many particle systems where fine particles need to be distributed throughout the continuous phase. *Dispersability* is defined as the ease with which particles are distributed in the continuous phase so that each particle is completely surrounded by the liquid phase and no longer makes a permanent contact with any other particles. Once a dispersion is created, the problem then becomes one of maintaining it, since particle systems have a natural tendency, starting with van der Waals forces, to coagulate and flocculate. Thus, dispersion is essentially the opposite side of the coin from coagulation and flocculation.

The particle size plays a key role in the degree of dispersion possible in any given particle system. Thus, we are now using Stokes law in the opposite way than previously noted in this module. If the particles are small enough, i.e., colloidal in nature (less than 1 micron), they are kept in suspension by simple Brownian movement. However, in systems containing coarser particles (greater than 1 micron), special attention is required to keep the system in a highly disperse state.

Generally the most practical way of maintaining dispersions is through the use of chemical stabilizers called dispersants. If the particle size is relatively narrow, the system is said to be *monodisperse*. If, however, the size distribution is broader in the particle size it contains, the system is called *polydisperse*.

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Web Page 8:

TYPES OF DISPERSANTS

The primary property of dispersants is their ability to disperse fine particles and to stabilize the dispersion. As the particles are dispersed within a continuous liquid phase, the interfacial area between the particle and the liquid phase increases. The action of the dispersant at this interface determines the behavior of the particle phase. In aqueous particle systems, dispersants generally have several hydrophilic groups along their chain and a hydrophobic backbone that is hydrocarbon in nature. The adsorbed dispersant molecules have a tendency to look like common hair combs and to lie more or less parallel to the particle surface. In this form, the polar (charged) groups are directed outward into the liquid medium.

There are a number of common classifications of dispersants, including lignin sulfonic acids, formaldehyde condensation products, polyphosphates, and water soluble low molecular weight polymers.

The lignin derivative is a naturally occurring polymer produced by the paper making process. The advantages of lignin sulfonic acid is the tend to adhere more strongly to hydrophobic particles and they are more stable relative to temperature increases. However, the major disadvantage is their tendency to foam and to discolor in the presence of light.

The second commonly used class of dispersants is formaldehyde condensation products, created by the condensation reaction of aromatic compounds with formaldehyde. These types of dispersants are widely used in pigment systems, abrasives, glues, rubber, and cleaning soaps.

Polyphosphates have long been used in cleaning detergents, coupled with low water-soluble calcium and magnesium soaps, for dispersing dirt detached from the fibers in clothes. The use of such dispersants improves with the degree of whiteness in the washed laundry. However, because of environmental problems related to algae growth when waters containing phosphates are exposed to natural water systems and water treatment plants, their use is decreasing rapidly in most areas of the world.

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Web Page 9:

DEFINITION OF A SURFACTANT

Surfactants, or surface active agents, have an amphipathic structure, that is, they contain two major structural groupings. First is a *lyophobic* group that has very little attraction for the continuous liquid phase or solvent phase. In aqueous systems this is the hydrocarbon portion, called the *hydrophobic tail* or simply *tail*, of the surfactant. The second major grouping is a lyophilic group which has a strong attraction for the liquid phase or solvent. In aqueous systems this is often an ionic portion or a nonionic portion containing oxygen; it is called the *hydrophilic head*, or simply *head*. The hydrophobic hydrocarbon tail has a weak affinity for water in an aqueous environment while the hydrophilic head has a strong affinity for water.

Surfactants are chemicals that preferentially adsorb onto the interfaces of the different phases present in a particle system. Typical particle systems in which surfactants are used include solid particles in a continuous aqueous phase, solid particles in a continuous hydrocarbon phase, air bubbles in aqueous fluids, organic or hydrocarbon droplets in aqueous fluids, and aqueous droplets in hydrocarbon fluids.

Surfactants significantly reduce the surface tension or interfacial free energy between phases. It is important to point out, however, that surfactants are not the only surface tension reducing chemicals. There are surface tension reducing chemicals that are not surfactants. In many applications, surfactants can be thought of as a chemical substitute for high levels of mixing and agitation which would be required to maintain a high interface area in the system.

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Web Page 10:

MAJOR CLASSES OF SURFACTANTS

There are four major groupings of industrially used surfactants. The first is the *anionic* surfactants, which, as a group, represents about 60% of the volume of all surfactants used

industrially. Typical anionic surfactants include carboxylic acids, sulfonic acids, sulfuric acid, alkyl xanthic acids, and polymeric anionics. Within this group, the most common chemicals used are sodium oleate; sodium lauryl sulfate; and dodecylbenzene sulfonic acid. The last two are the basic surfactants used in soap and cleanser products.

The second group is the *cationic* surfactants which as a group represent about 10% of the total volume of surfactants used. Typical cationic surfactants include long chain amines; diamines and polyamines; and ammonium salts.

The third group is *nonionic* surfactants, which represent about 25% of the total surfactant volume used in industry. Typical nonionic surfactants include polyoxyalkylenated alcohols; polyoxyethylenated glycols; and esters of carboxylic acids. The most common chemicals in this group used historically have been the polyoxyethylenated glycols; however due to stricter human health concerns involving surfactants, there has been a gradual shift to the use of other glycols which are safer. These type of surfactants are commonly used to control and maintain the size of air bubbles in aqueous systems.

The final group of surfactants is the *zwitterionic* surfactants (sometimes called amphoteric) which are about 5% of the volume of surfactant usage. Typical zwitterionic surfactants include acrylic acid derivatives; substituted alkylamides; and n-alkyl betaines. These chemicals, considered to be "speciality" surfactants, are more expensive than most of the other surfactants mentioned. Zwitterionic materials have, as their name implies, two different polar water associating groups within the same molecule. Zwitterionic surfactants are particularly useful in applications that require much different responses as a function of changing pH. This is the case with many skin and hair products as well as in mineral separation processes.

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Web Page 11:

APPLICATIONS OF SURFACTANTS

The industrial and consumer oriented uses of surfactants are numerous. Some common products and processes include paints, soaps, shampoos, cosmetics, pesticide application, fuel additives, food product preparation, fabric softeners, detergents, dry cleaning, and wood preservatives. In particular, the use of surfactants in suspensions, emulsions, foams, aerosols, and for controlling wettability of materials is common industry. It should be apparent that there is not a single day in our lives that passes without our coming into contact with a surfactant used in a particle system.

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Note: Items 11-20 are specific to the instructional module and therefore are used for data analysis.

APPENDIX G
Post-ASSESSMENT
Engineering Research Center (ERC) Particle Science and Technology

A National Science Foundation Engineering Research Center

From Instructional Module Series: Raj Rajagopalan, Series Editor
Introduction to Chemicals Used in Particle Systems by Richard R. Klimpel, Ph.D.

Directions: Please respond to the following items. For the short response items, prepare a clear and concise response directly on this sheet. Please turn your completed assessment in to the investigator when you are finished. Thank you for your cooperation.

I. General Chemistry Knowledge

______1. A transition element in the periodic table is

a. sodium b. sulfur c. boron d. aluminum e. chromium

______2. Two atoms which have the same atomic number but different mass numbers:

a. sisters b. mothers c. daughters d. isomers e. isotopes

______3. How does the periodic table substantiate atomic theory?

a. Both are theoretical and cannot support each other.

b. Groups in the table have similar properties based on the same number of valence electrons.

c. All elements in a period of the periodic table have the same number of valence electrons.

d. Mendeleev declared consistency between the periodic table and atomic theory.

e There are eight elements in every row of the periodic table.

______4. How many electrons can there be in the 3d level?

a. 2 b. 4 c. 5 d. 10 e. 8

______5. The number of protons in the nucleus of an atom is called the for the atom.

a. mass number b. family number c. electron number

d. atomic number e. group number

______6. A noble gas is

a. Al b. Ar c. Cl d. O e. C

______7. Which element is a metal?

a. neon b. chlorine c. sodium d. argon e. sulfur

8. Summarize the concept of titration using the terms neutralization, end-point, indicator, acid/base and pH appropriately.

9. State Charles and Boyles law by definition or equation and provide an application.

10. Briefly explain chemical bonding in terms of covalent and ionic bonds.

II. Chemicals and Particle Systems

______11. A substance that preferentially adsorbs onto the interfaces between two different phases is a

a. flocculant b. dewaterant c. coagulant d. dispersant e. surfactant

______12. surfactingWhat is the opposite of coagulation and flocculation?

a. polymerizing b. dewatering c. settling d. dispersion e. surfacting

______13. Removing surface water from particles is

a. flocculation b. dewatering c. coagulation d. dispersion e. surfacting

______14. Promoting the incorporation of fine particles into a liquid continuous phase so that the resulting system consists of fine particles uniformly distributed throughout the phase is

a. flocculation b. dewatering c. coagulation d. dispersion e.

15. How do surfactants assist cleansing action?

16. Name one common anionic surfactant.

______17. Zwitterions are sometimes called
a. amphoteric b. polymeric c. salts d. acids e. nonionic

18. Differentiate between "philic" and "phobic" materials.

19. What is the key implication of Stokes Law?

20. To be considered colloidal, particles are typically less than 1
a. millimeter b. micromhos c. micron d. microgram e. meter

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BIOGRAPHICAL SKETCH

Jace Hargis was born in Terre Haute, Indiana on January 1, 1962. He received his Bachelor of Science degree from Florida Institute of Technology in chemical oceanography in 1984 and his Master of Science in Environmental Engineering Sciences from the University of Florida in 1992. He began his professional career teaching high school chemistry for two years before he moved into the laboratory at CIBA-Geigy in Atlanta, Georgia, analyzing environmental and hazardous waste samples as a bench chemist. This position provided the experience which enabled him to work as a consulting environmental chemist for the past ten years with CH_2M Hill Environmental Engineering, Inc. in Gainesville, Florida, where he is currently employed. In addition, Mr. Hargis is working on a temporary educational technology grant position through the University of North Florida in Jacksonville, Florida. The grant is sponsored by the Partnership to Access Educational Resources (PAER), which is part of the Technological Research and Development Authority division of NASA. In this position, he assists in the development of a graduate course which encompasses electronic resources from NASA to pre- and in-service instructors through the Internet and video-conferencing. Mr. Hargis resides with his wife, Jeanine, in Jacksonville Beach, Florida.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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